

# Nano- Robotic's in Medication with Challenge's and it's Law's

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**Abstract:** *The application of nanorobotics in medicine offers previously unheard-of possibilities as well as formidable obstacles. Stakeholders can guarantee that this technology is developed ethically and responsibly by creating a thorough legislative framework that takes into account the special qualities of medical nanorobots. In order to promote innovation and protect public health and welfare, this framework should develop in tandem with technological breakthroughs. Future studies should keep examining the potential advantages of nanorobotics in medicine as well as the precautions that must be taken to reduce hazards.*

**Keywords:** NANOROBOTICS, SARAS, RMIS

## I. INTRODUCTION

An developing area called "nanorobotics" combines nanotechnology with autonomous and teleoperated robotics to provide breakthroughs not possible with standard robotics. Nanorobots, which are tiny mechanical or electromechanical devices made to do certain tasks at the nanoscale, are at the center of this field. Nanorobots are active, controlled devices that can carry out complex tasks at the molecular and cellular levels, in contrast to passive nanoparticles, which are frequently employed for purposes like drug delivery. Medical robotics' trend toward downsizing is gaining traction and has the potential to revolutionize biomedicine. Applications such as targeted medication administration, single-cell manipulation, biosensing, tumor therapy, medical diagnosis, and even minimally invasive surgery are being investigated for micro- and nanoscale robots, which range in size from millimeters to just a few nanometers. This shift to smaller-scale operations is a reflection of a larger scientific advancement, from microbiology to germ theory, where each new level of knowledge has transformed healthcare. Researchers may modify matter at the atomic and molecular levels using nanotechnology, which is defined as a science carried out at the nanoscale (about 1 to 100 nanometers). This leads to revolutionary developments in materials and medicine. For example, nanotechnology has made it possible to create nanoparticles in oncology that may specifically target cancer cells while sparing healthy ones. Additionally, the field supports biosensing, improved imaging, and minimally invasive therapies. According to estimations, the global market for nanotools and nanodevices increased from \$1.5 billion in 2006 to a projected \$8.6 billion in 2011, demonstrating the quick economic growth in this industry. Molecular nanotechnology seeks to precisely engineer machine systems at the molecular level, going beyond ordinary nanomaterials. One important use of nanotechnology is nanomedicine, which employs molecular tools to improve human health.

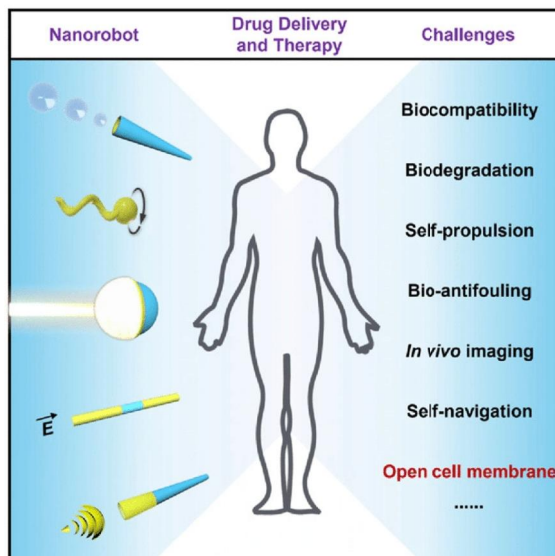
It encompasses nanorobotic devices such as diamondoid structures, modified biological systems, and nonbiological nanomaterials. We can anticipate developments like genetically modified biological robots, customized therapies based on proteomics and genomics, and artificial organic medical equipment in the near future. The merger of nano-, bio-, and information technologies is thought to be ushering in the nanotechnological era, a sixth technological paradigm as civilization develops. In addition to scientific promise, this change raises significant moral and legal issues, particularly with regard to technology that function inside the human body and violate established physical rules.

In response, scholars are creating theoretical and legal frameworks to mitigate these risks; future policy proposals and legal reforms are informed by comparative analyses of regulations in nations such as China, Russia, the United States, Japan, and the European Union.



## II. DESIGN & ARCHITECTURE OF MEDICAL NANOROBOTS:

A difficult balancing act between science, engineering, and biology is necessary when designing nanorobots for medical applications. These robots must have a safe and efficient structure because they must function inside the human body. Medical nanorobot materials are usually biocompatible and biodegradable, which means they won't damage the body or cause an immunological reaction. Metals, certain polymers, and even custom designed DNA structures are examples of common materials. Nanorobots require compact yet dependable power sources to operate inside the body. These can include chemical reactions involving bodily fluids, externally controlled magnetic fields, or even remotely activated ultrasonic waves. Another crucial component of their design is their communication strategies. While some nanorobots employ chemical signaling to communicate with their environment or transmit data to external devices, others are capable of sending and receiving signals wirelessly. At such a small scale, navigating the human body is difficult. Nanorobots employ a variety of locomotion and navigation strategies, including as following chemical gradients to reach certain targets like tumors or infection sites, using external magnetic fields for guidance, or moving with the aid of flagella-like structures. Lastly, the way nanorobots function is determined by control systems. Some are autonomous, which means they can make choices based on environmental inputs and preprogrammed logic. Others are teleoperated, which enables real-time remote control by medical professionals or researchers.



**Figure 1.**Challenges of nanorobots in drug delivery.

This image throws light on the various challenges that different shaped nanorobots face when employed for drug delivery [38].

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## III. USE OF NANOROBOTS IN MEDICAL APPLICATIONS

### Surgical Applications:

By increasing the accuracy and effectiveness of medical treatments, nanorobots are shown extraordinary promise in surgical applications. Developed in the early 2000s and later in 2016, systems such as SARAS (Smart Autonomous Robotic Assistant Surgeon) are intended to support surgical teams by managing duties that might otherwise increase their workload. Better patient outcomes may result from this assistance's ability to shorten operating times and enhance overall resource management. In a similar vein, Robotic Minimally Invasive Surgery (RMIS) systems—like the well-known da Vinci Surgical System—use small robotic instruments to carry out precise, delicate operations. These devices enable surgeons to carry out complicated treatments more effectively and with better control by fusing human talent with robotic precision.



Nanorobot-assisted surgeries promise improved precision, reduced invasiveness, and quicker operation times, according to extensive testing of such systems. The capacity of nanorobots to integrate with materials like quantum dots and colloidal gold, which have special structural and chemical characteristics not found in larger-scale instruments, is another important benefit. Because of this integration, nanorobots may perform extremely specialized jobs like cellular tumor targeting and treatment. Nanorobots can greatly increase therapy efficacy and minimize negative effects by delivering therapeutic substances directly to sick cells while protecting healthy ones. These developments demonstrate the expanding potential of nanorobotics to change surgical procedures and enhance patient care.

#### **Drug Delivery :**

Nanorobots have the potential to completely transform drug delivery by increasing the speed, effectiveness, and specificity of therapies. These tiny devices have built-in sensors that allow them to discover and identify unhealthy or infected parts of the body with amazing accuracy. They can autonomously or remotely administer therapeutic medications where they are required once they arrive at the target spot, frequently removing the need for invasive operations. In addition to improving therapeutic efficacy, this strategy—known as targeted medication delivery—also lessens the negative side effects that are frequently connected to conventional systemic medicines. Janus nanorobots, which have a dual-sided design—one active and one passive—allowing them to react differentially to environmental inputs, are among the cutting-edge technologies in this sector.

Their ability to transform a variety of energy sources into motion allows them to move quickly and precisely throughout the human body, delivering medications straight to the tissues that need them. Furthermore, some nanorobots overcome the difficulties of navigating intricate surroundings inside the human body by imitating biological movements, such as the flagella of bacteria, to swim through internal fluids. These nanorobots can be modified with biological ligands for better targeting capabilities and are frequently constructed from materials like liposomes, dendrimers, or carbon-based nanoparticles. They can contain a variety of antimicrobial compounds, such as peptides and antibiotics, and they can be made even better by using artificial intelligence (AI). AI is essential because it allows nanorobots to function independently, adjust to changing conditions, and make decisions in real time. For instance, they can optimize the timing and location of medicine delivery, modify their travel routes, and identify biomarkers at infection locations. To find the ideal circumstances for medication release, AI can even examine variables like pH, temperature, or bacterial activity. A new age in nanomedicine and more effective treatments are made possible by this intelligent, responsive technology that guarantees the delivery of medications with the least amount of waste and optimum efficiency.

#### **Challenges:**

Micro- and nanorobots have become a ground-breaking combination of robotics and nanotechnology over the last 10 years, with enormous potential for resolving challenging healthcare issues. These tiny devices are being built with a variety of architectures and propulsion technologies to efficiently carry out specific functions. We are still in the early phases of comprehending and utilizing their potential in medicine, though. More study and development are needed to fully realize their potential, particularly for performing complex surgeries in parts of the body that are now inaccessible. The adaptive intelligence of biological organisms—which includes great mobility, flexible structures, fine control, and even the capacity for self-evolution and replication—must be emulated by future nanorobots. Creating safe, biocompatible energy sources for the human body's long-term, autonomous operation is a significant task. Many chemical fuels and external stimuli, such as hydrogen peroxide, have been investigated, but their short lifespans or safety problems make them unsuitable for in vivo application. Although promising alternatives are being investigated, such as powering enzyme-based nanomotors with urea or blood glucose, their stability and efficacy still need to be improved. Making sure nanorobots can operate efficiently in complex tissues and viscous body fluids, where mobility and performance are more challenging to attain, is another challenge. Because of this difficulty, materials science is essential since the success of nanorobots is mostly determined by their surface and structural characteristics.



Nanorobots must be constructed from intelligent, responsive, and biodegradable materials that can change with their surroundings and prevent immunological reactions in order to safely travel the body. For the production of high-quality nanorobots on a wide scale and at a fair cost, innovations like 3D nano-printing will be essential. In the future, it is anticipated that millions of nanorobots would collaborate to carry out activities like focused drug administration or large-scale detoxification. Replicating the coordinated intelligence shown in nature is still a significant challenge, even though researchers have started investigating individual and group behaviors. Precision medicine may reach a new level if machine learning and nanoscale group planning are used to improve swarm intelligence. Additionally, the passage highlights important prospects and concerns in areas including biocompatibility, transport and targeting, control and navigation, and the ethical issues surrounding the use of nanorobots in healthcare.

#### **IV. THREE LAWS OF NANORBOTICS:**

Applying Isaac Asimov's three laws of robotics to nanorobotics offers a useful foundation for comprehending how these minuscule devices need to operate, particularly in delicate medical settings. The ethical and practical design of nanorobots functioning inside the human body can be guided by these guidelines, which were first developed for fictitious robots.

##### **First Law of Nanorobotics: Do No Harm**

**Asimov's first law**—"A robot may not harm a person"

It is particularly crucial when considering how nanodevices function within the human body. It highlights the necessity of biocompatibility, which means that the materials utilized in nanorobots must not result in unfavorable biological reactions. This covers tissue and cell damage, toxicity, and immunological reactions. Foreign substances may cause the body to react in a variety of ways, and while within the body, the substances may undergo changes that could impact how they work. It is therefore essential to use polymers and organic compounds that resemble genuine cells and tissues. Additionally, issues including waste byproducts, immunogenicity, and radiation from the device need to be properly taken into account. The replication of these devices inside the body is another important concern, which, if improperly managed, might present major legal and safety issues.

##### **Second Law of Nanorobotics: Self-Preservation Without Harm**

As long as it doesn't go against the first law, the second law requires a nanorobot to maintain its own existence. This means that in medical applications, the robot must be operational long enough to do its duty, such as delivering medication or focusing on tumor cells. For example, nanorobots undergo a number of stages in the treatment of cancer, from being injected into the bloodstream to eventually infiltrating and functioning within tumor cells. However, the robot encounters a number of difficulties along the way. It may be covered in proteins in the circulation, creating a "protein crown" that modifies its function and behavior. Additionally, it might be targeted by immune cells or find it difficult to pass across natural barriers like the blood-brain barrier. The usefulness of the nanorobot may be diminished by these challenges, thus designers must make sure the robot can endure and operate long enough to produce significant therapeutic outcomes.

##### **Third Law of Nanorobotics: Obedience with Limits**

Asimov's third law is that a nanorobot must obey human commands unless doing so would go against the first or second law. This translates into responsiveness and controllability in nanorobotics. Movement, drug release, and targeting commands must be obeyed by a nanorobot without endangering its goal or inflicting harm. Technologies that use internal cues like chemical gradients or external signals like magnetic fields are being developed to help regulate these devices. Certain nanorobots can even react to elevated glucose or inflammation by approaching the afflicted regions. Despite these developments, it is challenging to standardize responses across all patients due to individual variability in human biology, such as changes in receptor expression on cells. Therefore, even though nanorobots can be programmed and steered, it is still difficult to foresee every interaction that occurs within the human body.



In conclusion, we have a solid ethical and technical basis when we reinterpret Asimov's laws for nanorobots. It acknowledges the biological complexity and unpredictability of operating inside the human body while highlighting the significance of safety, functionality, and human control.

## V. CONCLUSION

With the potential to completely transform how we identify, treat, and even prevent illnesses, nanorobotics in medicine is a cutting-edge field. Medical nanorobots that are able to carry out extremely precise activities at the cellular and molecular levels are emerging as nanotechnology advances. These tiny devices are creating previously unthinkable opportunities for everything from tailored medication delivery and minimally invasive surgeries to real-time diagnostics and biosensing. But this exciting field also presents a number of difficulties, from toxicity and biocompatibility to moral and legal issues, particularly when devices function independently inside the human body. The next generation of safe, efficient, and intelligent medical nanorobots will be greatly influenced by the combination of artificial intelligence, sophisticated materials, and molecular manufacturing as researchers strive to address these challenges. Even though nanomedicine is still in its infancy, it has a bright future ahead of it. With sustained research and ethical innovation, it has the potential to completely change healthcare for future generations.

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