# BLOG ARTICLE

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## Nanotechnology in Medicine - Nanomedicine

The use of nanotechnology in medicine offers some exciting possibilities. Some techniques are only imagined, while others are at various stages of testing, or actually being used today.

Nanotechnology in medicine involves applications of nanoparticles currently under development, as well as longer range research that involves the use of manufactured nano-robots to make repairs at the cellular level (sometimes referred to as *nanomedicine*).

Whatever you call it, the use of nanotechnology in the field of medicine could revolutionize the way we detect and treat damage to the human body and disease in the future, and many techniques only imagined a few years ago are making remarkable progress towards becoming realities.

### Nanotechnology in Medicine Application: Drug Delivery

One application of nanotechnology in medicine currently being developed involves employing nanoparticles to deliver drugs, heat, light or other substances to specific types of cells (such as cancer cells). Particles are engineered so that they are attracted to diseased cells, which allows direct treatment of those cells. This technique reduces damage to healthy cells in the body and allows for earlier detection of disease.

For example, nanoparticles that **deliver chemotherapy drugs directly to cancer cells** are under development. Tests are in progress for targeted delivery of chemotherapy drugs and their final approval for their use with cancer patients is pending. One company, CytImmune has published the results of a **Phase 1 Clinical Trial** of their first targeted chemotherapy drug and another company, BIND Biosciences, has published preliminary results of a **Phase 1 Clinical Trial** for their first targeted chemotherapy drug and is proceeding with a **Phase 2 Clinical Trial**.

Researchers at the Wyss Institue are testing nanoparticles that release drugs when subjected to sheer force, such as occurs when passing through a section of artery that is mostly blocked by a clot. Lab tests on animals have shown that this method is effective in delivering drugs used to dissolve clots.The  Read more about their study **here**.

Researchers at the Houston Methodist Research Institute have demonstrated a targeted drug delivery method in mice using **silicon nanoparticles** that degrade inside a tumor, releasing polymer strands that form a nanoparticle containing the drug to be delivered. This polymer nanoparticle dissolves inside the cancer cell, delivering the drug to the cancer cell.

Researchers at the University of Illinois have demonstated that **gelatin nanoparticles** can be used to deliver drugs to damaged brain tissue more efficently

than standard methods. This has been demonstrated in the lab, the researchers hope that this method will result in more effective drug delivery for brain injuries.
Researchers at MIT are investigating the use of **nanoparticles to deliver vaccine**.The nanoparticles protect the vaccine, allowing the vaccine time to trigger a stronger immune response as shown in lab tests with mice. Additional work needs to be done to adapt the technique to human patients.

Reserchers are developing a method to release insulin that uses a **sponge-like matrix that contains insulin as well as nanocapsules** containing an enzyme. When the glucose level rises the nanocapsules release hydrogen ions, which bind to the fibers making up the matrix. The hydrogen ions make the fibers positively charged, repelling each other and creating openings in the matrix through which insulin is released. So far this has been shown to be effective in tests with lab mice.

Researchers are developing a **nanoparticle that can be taken orally** and pass through the lining of the intestines into the bloodsteam. This should allow drugs that must now be delivered with a shot to be taken in pill form. The researchers have demonstrated the technique with lab mice so far.

Researchers are also developing a nanoparticle to defeat viruses. The nanoparticle does not actually destroy viruses molecules, but delivers an **enzyme that prevents the reproduction of viruses molecules** in the patients bloodstream. The effectiveness of the technique has been demonstrated in lab tests.
Read more about **nanomedicine in drug delivery**

### Nanotechnology in Medicine Application: Therapy Techniques

Researchers have developed "nanosponges" that absorb toxins and remove them from the bloodstream. The **nanosponges** are polymer nanoparticles coated with a red blood cell membrane. The red blood cell membrane allows the nanosponges to travel freely in the bloodstream and attract the toxins.
Researchers have demonstrated a method to generate sound waves that are powerful, but also tightly focused, that may eventually be used for noninvasive surgery. They use a **lens coated with carbon nanotubes** to convert light from a laser to focused sound waves. The intent is to develop a method that could blast tumors or other diseased areas without damaging healthy tissue.

Researchers are investigating the use of **bismuth nanoparticles** to concentrate radiation used in radiation therapy to treat cancer tumors. Initial results indicate that the bismuth nanoparticles would increase the radiation dose to the tumor by 90 percent.

Nanoparticles composed of polyethylene glycol-hydrophilic carbon clusters (PEG-HCC) have been shown to **absorb free radicals** at a much higher rate than the proteins out body uses for this function. This ability to absorb free radicals may reduce the harm that is caused by the release of free radicals after a brain injury.
Targeted heat therapy is being developed to destroy breast cancer tumors. In this method antibodies that are strongly attracted to proteins produced in one type of breast cancer cell are attached to nanotubes, causing the nanotubes to accumulate at the tumor. Infrared light from a laser is absorbed by the nanotubes and produces **heat that incinerates the tumor**.

## Nanotechnology in Medicine Application: Diagnostic Techniques

Researchers at MIT have developed a sensor using carbon nanotubes embedded in a gel; that can be injected under the skin to **monitor the level of nitric oxide** in the bloodstream. The level of nitric oxide is important because it indicates inflamation, allowing easy monitoring of imflammatory diseases. In tests with laboratory mice the sensor remained functional for over a year.

Researchers at the University of Michigan are developing a sensor that can detect a very low level of cancer cells, as low as 3 to 5 cancer cells in a one milliliter in a blood sample. They grow sheets of **graphene oxide**, on which they attach molecules containing an antibody that attaches to the cancer cells. They then tag the cancer cells with fluorescent molecules to make the cancer cells stand out in a microscope.

Researchers have demonstrated a way to use nanoparticles for **early diagnosis of infectious disease**. The nanoparticles attach to molecules in the blood stream indicating the start of an infection. When the sample is scanned for Raman scattering the nanoparticles enhance the Raman signal, allowing detection of the molecules indicating an infectious disease at a very early stage.

A test for early detection of kidney damage is being developed. The method uses **gold nanorods** functionalized to attach to the type of protein generated by damaged kidneys. When protein accumulates on the nanorod the color of the nanorod shifts. The test is designed to be done quickly and inexpensively for early detection of a problem.

## Nanotechnology in Medicine Application: Anti-Microbial Techniques

Researchers at the University of Houston are developing a technique to kill bacteria using **gold nanoparticles and infrared light**. This method may lead to improved cleaning of instruments in hospital settings.

Researchers at the University of Colorado Boulder are investigating the use of **quantum dots** to treat antibiotic resistant infections.

Researchers at the University of New South Wales are investigating the use of **polymer coated iron oxide nanoparticles** to treat chronic bacterial infections.

One of the earliest nanomedicine applications was the use of **nanocrystalline silver** which is  as an antimicrobial agent for the treatment of wounds, as discussed on the **Nucryst Pharmaceuticals Corporation** website.

A nanoparticle cream has been shown to fight staph infections. The **nanoparticles contain nitric oxide gas**, which is known to kill bacteria. Studies on mice have shown that using the nanoparticle cream to release nitric oxide gas at the site of staph abscesses significantly reduced the infection.

Burn dressing that is coated with **nanocapsules containing antibotics**. If a infection starts the harmful bacteria in the wound causes the nanocapsules to break open, releasing the antibotics. This allows much quicker treatment of an infection and reduces the number of times a dressing has to be changed.

A welcome idea in the early study stages is the **elimination of bacterial infections** in a patient within minutes, instead of delivering treatment with

antibiotics over a period of weeks. You can read about design analysis for the antimicrobial nanorobot used in such treatments in the following article: **Microbivores: Artifical Mechanical Phagocytes using Digest and Discharge Protocol**.

### Nanotechnology in Medicine Application: Cell Repair

Nanorobots could actually be programmed to repair specific diseased cells, functioning in a similar way to antibodies in our natural healing processes. Read about design analysis for one such cell repair nanorobot in this article: ***The Ideal Gene Delivery Vector: Chromallocytes, Cell Repair Nanorobots for Chromosome Repair Therapy***

### Nanotechnology in Medicine: Resources

National Cancer Institute Alliance for Nanotechnology in Cancer; This alliance includes a **Nanotechnology Characterization Lab** as well as eight **Centers of Cancer Nanotechnology Excellence**.
**Alliance for NanoHealth**; This alliance includes eight research institutions performing collaborative research.

**European Nanomedicine platform**
The National Institute of Health (NIH) is funding research at eight **Nanomedicine Development Centers**.

Lets get you started by answering the following:

**After reading the article:**

1. **Research one type of nanoparticle used in medicine.**
2. **Describe it's structure (What is it made out of?) and it's function (What does it do?) as well as how its structure relates to its function (How does the structure allow for the particle to do what it does???)**
3. **Why is the type of nanoparticle you chose to focus on well suited to do "its job" as opposed to the others mentioned in the article? (Is this particular nanoparticle built particularly well for doing its job? How so???)**
4. **State your opinion. What do you think about nanotech. Its a growing field! Do you think thats a good thing? Elaborate on your own thoughts and opinions about this growing field of technology. Feel free to base your option of a little more googling!**