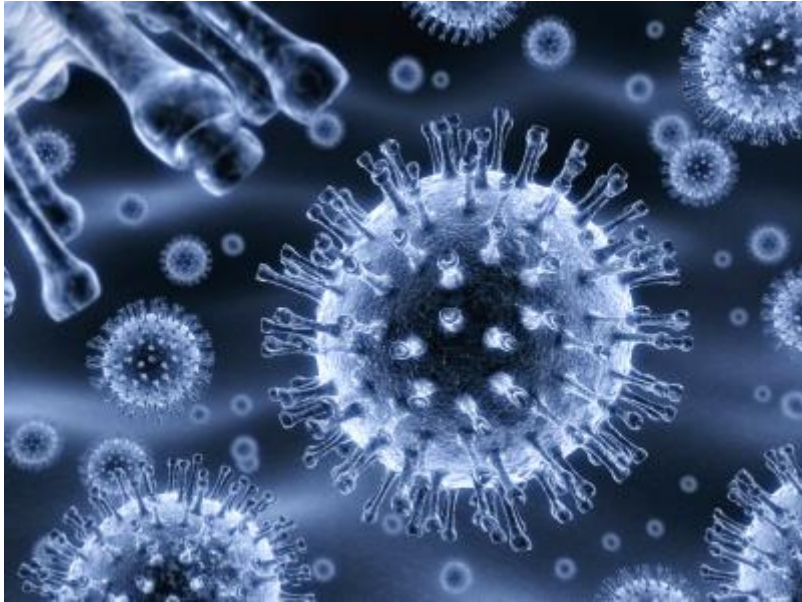


# NANOTECHNOLOGY IN MEDICINE



BY  
GAURAV MEHTA

PASS

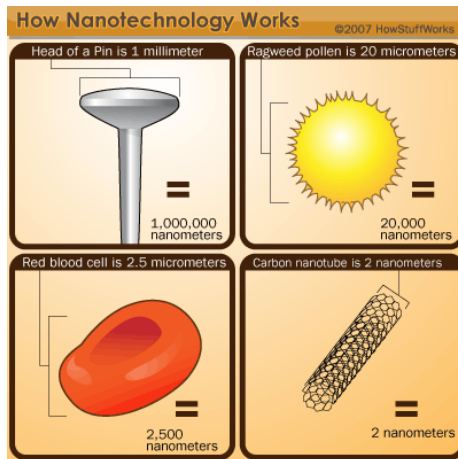
RESEARCH PAPER  
BASED ON  
PATHOLOGY LECTURES  
AT MEDLINK 2010

## ABSTRACT

The use of nanotechnology in medicine has progressed rapidly over the past few years. Recent developments have brought about promise for the use of nanotechnology in treating cancers and drug delivery, for example. I will outline some current uses of nanotechnology in the medical field, and how they are improving medical techniques. I will also carry out research in future developments of nanomaterials, and how they could have drastic effects in fields such as surgery. It is also important to consider drawbacks of such methods, which I will mention and outweigh with their advantages.

## INTRODUCTION

Nanotechnology is to do with the engineering of systems at a molecular scale, as indicated by the name. A nanometre is one billionth of a metre, and nanoparticles use this property to their advantage. Nanotechnology has progressed far since it arose from theories by James Clerk Maxwell in 1867, with his ‘thought’ experiment of handling molecules. Nanotechnology has become more ‘popular’ and more of a talking point in the 20<sup>th</sup> century, thanks to the work of K. Eric Drexler.



Nanotechnologies are used for the production of nanoparticles, nanopowders or nanotubes. Rare earth compounds such as oxides are being discovered, for example, iron nanoparticles, iron oxide nanopowder and many more have been discovered, enhancing technologies in fields such as engineering and even in medical treatment. It is expected that nanotechnology will impact almost every industry, and the market for nanotechnology will be worth £1trillion in the next few decades.

Medicine has excelled with the use of nanotechnology.

**FIGURE 2.** Fields include drug delivery systems and development of stem cells.

### Nanotechnology as Liposomes

Liposomes come under nanoparticles and are artificially prepared from the phospholipid bilayer. They are used as drug delivery devices due to the several properties they exhibit. Their most important properties are their colloidal sizes, which range from 20nm to 10micrometres. In addition, they also possess mechanical properties such as permeability, charge density and the presence of surface bound or grafted polymers. Their biological properties enable them to interact efficiently with other biological substances such as cell membranes.

Benefits of liposomes are endless, including their ‘site-avoidance’ mechanism – this is essential as it ensures liposomes are not deposited in regions such as the brain, heart and nervous system, overall reducing the effect of cardio- and neuro-toxicity. Liposomes being site specific improves their efficacy. They can therefore bind to specific cells via the ‘key and lock’ or ‘induced fit’ mechanism. They may also be transported through badly formed blood vessels and capillaries, and examples include anticancer drugs. As a result of their

phospholipid structure, transport of polar, hydrophilic molecules is improved, such as genes into cells; and they also have better penetration.

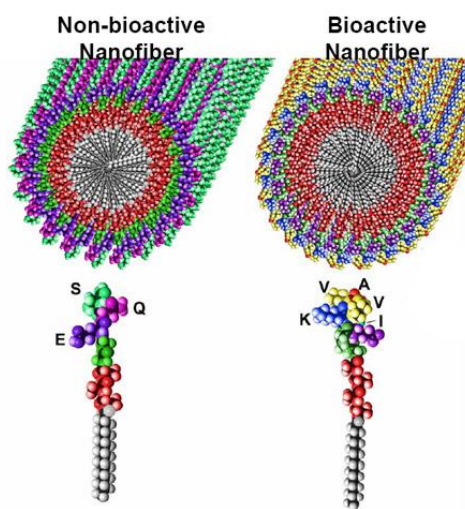
#### Liposomes for parasitic disease and infection

Conventional liposomes are digested by phagocytic cells in the body and are ideal for the targeting of drug molecules into macrophages. An example of a parasitic infection is leishmaniasis, affecting over 100,000 million people worldwide and can cause death. Because liposomes gather in the same body tissues, they can be used as a drug delivery 'vehicle'. Due to current research, there have been various formulations of liposomal methods in humans. Amphotericin B has been developed for use in anti-fungal therapies. Although extremely useful, this drug is very toxic due to its nephro- and neuro- toxicity, hence its dosage has to be reduced. Trials proved that terminally ill patients who couldn't be aided by conventional therapies and many other patients were successfully treated Amphotericin B formulations. Liposome manufacturing still take a lot of thought because of the undesired way these molecules interact with bilayers and other substances of differing densities.

## DISCUSSION

Nanotechnology in medicine is ever-growing. Currently, advances in drug delivery systems are taking place, however, the development of ‘nanorobots’ seems to be an area less known, despite its medical possibilities. I will therefore attempt to give an in-depth analysis of this innovation. Surgical in vivo nanorobots could be developed, introducing them to the body via catheters into certain vessels and other internal cavities. Their uses could be endless, because once manufactured they could be programmed for several different functions, including the elimination of cancerous cells and the exchange of chromosomes between totally different cells. These devices, once programmed by a human surgeon, could undergo semi-autonomous operations within the human body. Hence, they could perform pathologies and diagnosis by nanomanipulation, and there would be external communication with the human surgeon by ultrasound transmission. Nanosurgery does exist in its early stages, for example, a vibrating micropipette tip for the extraction of damaged dendrites from single neurons, without causing any further damage. Nanorobots may be developed equipped with modes of transport to specific sites, and instruments to carry out accurate cellular surgeries, far more advanced than operations by man.

Research by Dr. Mauris N. De Silva could prove crucial in the regeneration of nerve cells using nanotechnology. This issue has great significance in the medical sector as the regeneration of nerve cells could reduce traumatic effects and disease. Research has shown how magnetic nanoparticles may be used to create physical tension, stimulating growth of the CNS (central nervous system) neuron axons. Another method may involve the use of nanofibres containing an intrinsic nutrient-rich ‘environment’ for growth and repair of nerve



cells. The first method involves the injection of the mechanical nanomaterial, resulting in outgrowth of nerve projections. Research carried out on optic nerves has had positive results of magnetic nanoparticles induced within sites of nerve injury. It is important to realise that these stages are very early in the developments of these materials, and could prove crucial for future innovations.

Peripheral nerve injury is of great concern. It affects millions of people worldwide, and causes loss of sensory and motor functions. These nerves are able to self-regenerate, unless the gaps between the

**FIGURE 3.** nerves are bigger than a few millimetres in size. This is often treated by nerve transplantation, which itself is an advanced operation. There are also many drawbacks of this, for example, the donor may suffer from loss of nerve functions themselves, and numerous surgeries are required for a successful operation. New innovations in the medical field could solve this problem. The use of polymer fibres (on a nanoscale) could act as physical guides for regenerating nerves cells. The formation of these materials involve creating a micro-

environment, thus providing biochemicals and possessing physical qualities just as 'normal' nerves would. The speed of this operation is key in enabling growth of nerves.

Studies on animals have shown positive effects using aligned nanofibre scaffolds, rather than unaligned ones. The formation of a micro-environment has also induced rapid nerve generation. Clinical uses may be advanced by the 'spinning' of nanofibres to form tubular nerve grafts.

It is clearly interpretable that the methods I have proposed have drawbacks, some of which may be extremely difficult to suppress, such as ethical issues. As I previously mentioned, these new creations are tested for success rate, and also any potential dangers. It is inevitable that the testing on animals would cause upsets.

Costs of carrying out research may be extremely large, and if research is subsidised by authorities then funds may have to be cut in the sectors of the society. This is unacceptable for some, considering research put into the nano-industry may not be effective. Currently, spending on nanotechnology in the EU is expected to be between €300-400 million, and expected to reach €3.5 billion by 2013, with an overall budget of €50.5 billion. This is infeasible if research is ineffective, especially if there are suspected dangers to the use of nanomaterials.

It may so happen that nanofibres may not be accepted or recognised by host cells, resulting in a waste of resources.

In addition, with nanoparticles come nanopollutants. This risk is valid at the moment, and still will be for future developments. The smaller the particles are, the more of them there are present in a certain area. This means they have greater penetrating forces, and if inhaled they may potentially cause lung disease. Industrial workers dealing with products containing nanomaterials are at high risks.

Despite sounding far-fetched, it may be theoretically possible that nanorobots could multiply and invade host cells. This is certainly a talking point for opposing parties towards developments of nanorobotics.

## CONCLUSION

Nanotechnology offers a wide range of uses in medicine. Innovations such as drug delivery systems are only the beginnings of the start of something new. As we have seen, it is only a matter of time until nanorobots will play a major role in the medical field. It is important to take into account both advantages and disadvantages of the methods I have mentioned.

I feel there are endless benefits to the uses of nanotechnology. Due to their physical properties, they obtain special properties. Drug delivery systems enable transportation of drugs to specific sites, resulting in more efficient medication. Nanorobots may be developed that overcome current surgical problems, such as nerve transplantations. In addition, nanorobots would offer more accurate surgeries, within ranges of a few millimetres, incapable by a normal human hand.

However, as I mentioned previously, there are also some drawbacks. Adverse effects may include inhalation of nanomaterials, which may penetrate deep into tissues and cause long term damage. The development of nanorobots may mean sever changes in the industry, maybe resulting in reduction of jobs due to newer, more efficient nanoparticles. This links with the ethical issues of nanotechnology – is it worth investing in nanotechnology today if we are unsure about the outcome and associated risks in the future?

Overall, I believe that the nano-industries are developing rapidly, however, still trying to ensure drawbacks are minimised. Research is being carried out for the benefit of society, and funds are being received to overcome any problems. An example would include liposomes as drug delivery systems. Although being efficient in their tasks, they may carry highly toxic traces of certain elements. This has been minimised by encapsulation of liposomes. Such research and methods indicate growth in the safe and efficient use of nanomaterials in the medical industry.

# Bibliography

<http://www.crnano.org/whatis.htm>

[http://en.wikipedia.org/wiki/History\\_of\\_nanotechnology](http://en.wikipedia.org/wiki/History_of_nanotechnology)

<http://www.americanelements.com/nanotech.htm>

<http://mritechnicianschools.net/2010/25-ways-nanotechnology-is-revolutionalizing-medicine/>

<http://www.dr-baumann-international.co.uk/science/Applications%20of%20Liposomes.pdf>

<http://www.futureforall.org/nanotechnology/risks.htm>

<http://www.nanomedicine.com/Papers/IntJSurgDec05.pdf>

[http://www.pharmasm.com/pdf\\_files/Umalkar.pdf](http://www.pharmasm.com/pdf_files/Umalkar.pdf)

<http://www.nanowerk.com/news/newsid=1651.php>

<http://www.sciencentral.com/video/2008/02/15/nano-pollution-and-health/>