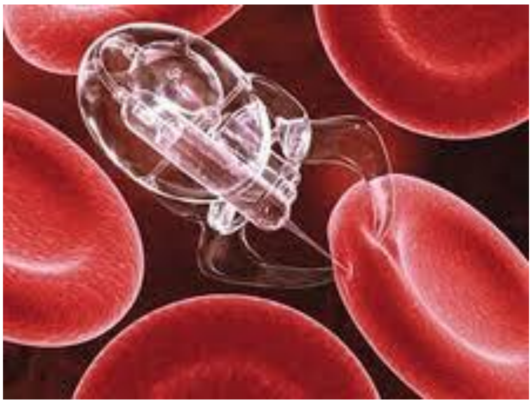
NANOTECHNOLOGY IN MEDICINE
Innovations and Development in Drug Delivery Systems



BY

RACHEL VEERAVALLI

PASS

RESEARCH PAPER
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ABSTRACT

Nanotechnology gives the ability to work at a molecular level which allows for greater manipulation of material, and also gives a wide variety of areas where nanotechnology can be 'the way forward'. This paper aims to discuss the new techniques and the advances brought to drug delivery systems by the application of nanotechnology. There are many exciting prospects for nanotechnology in this field.

INTRODUCTION

Nanotechnology is set to be the technology of the future, and the number and range of uses of nanoscience is vast, and in a way, still unforeseeable at this time. The uses of nanotechnology can range from nanoclays and nanocomposites which are used to produce light weight packaging, and which also give a longer shelf-life, to nanoparticles from which synthetic bone material can be based, to resemble the constitution of natural bone. Figure 1 shows the structural levels of bone construction, which researchers try to match at a nanoscale when designing and constructing the synthetic material.

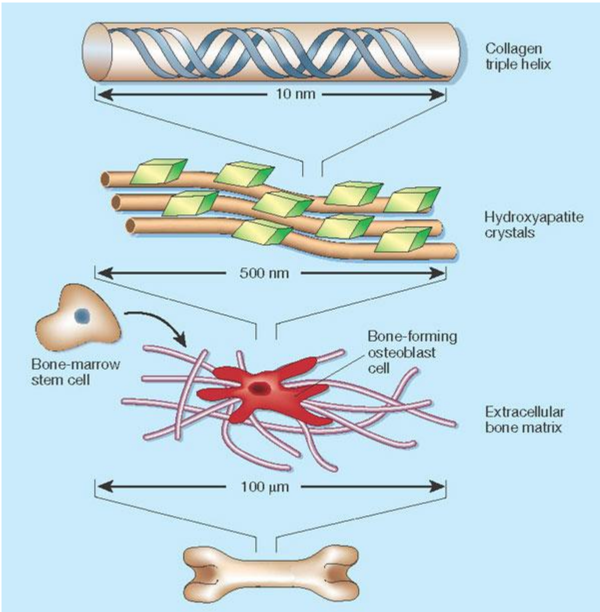

figure 1

Being able to manipulate anything at such a small, molecular level consequently gives one the great advantage of assembling an object, which could be of almost any sort due to the diversity of nanotechnological applications, with skillful precision, accuracy and detail. Therefore, it has become possible to create highly efficient materials, which are gradually being incorporated more and more into our daily lives. One example of such a material is self-cleaning window glass, which includes a microcrystalline titanium oxide coating. The concept of 'self-cleaning' was discovered by botanist Wilhelm Barthlott in 1973, whose inspiration for the idea came from the lotus plant. This is not the only case where nature has been involved in nanoscience, with many designs, and even ideas on how to implement the nanotechnology, have been influenced by nature.

However, we would not have arrived at where we are today if it was not for the thoughts put forward by Richard Feynman in 1959, who was the first to suggest that it would be possible to manipulate objects at a molecular scale. Since then, nanotechnology has progressed, with increasing momentum, and I believe will continue to develop in this way for quite some time.

From the multitude of diverse options, one of the many fields, in medicine alone, that nanotechnology can be applied to is drug development and delivery systems, areas in which this science is only just beginning to make an impact. Nanoscience can be involved throughout the entire process of drug development which precedes the actual administration of any drug. A general process of drug development may begin with a method that includes computer-aided searches to find the chemical or chemicals which induce a desired affect on the target compound. When this has been discovered, there is adjustment of the compound found to comply with safety standards and to improve it, so that the best result possible is obtained from the use of the drug. In total, up to 14 years of research and development can be invested in a drug before it can be marketed. However, one technique nanotechnology has brought to drug discovery is the use of microfluidics and nanofluidics. Micro- and nano- fluidics can be used to find small groups of cells or molecules, and in cases, even single cells or molecules, and analyze them expeditiously, segregate them, and then finally develop the required cell or chemical prior to marketing and release to potential buyers and users of the drug. Therefore, the entire process of drug development with the involvement of nanoscience could become considerably quicker, result in more reliable results, and bring about more effective and satisfying outcomes for the drug user. (Figure 2 represent water being transported in a carbon nanotube, which is involved in microfluidics.)

The main focus of this paper is the application of nanotechnology when it comes to the administration of a drug. However, by briefly outlining the important role that nanotechnology can also play in drug development, which is closely associated with drug delivery, just one example of how nanotechnology is used in many different ways in one field alone, is demonstrated to you. Also, this information may act as helpful background knowledge to you, when we come to discuss drug delivery systems.

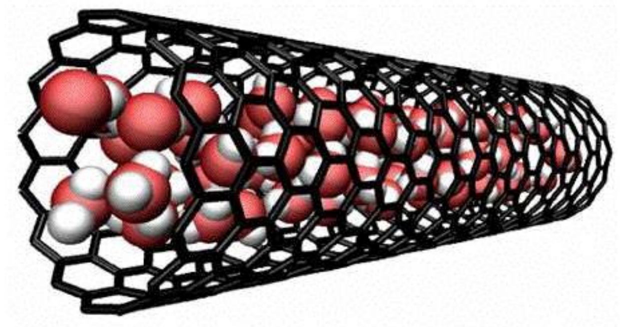

figure 2

DISCUSSION

When talking about drug delivery systems, nanotechnology can simply be described as a breakthrough. So many existing methods of drug administration have been revolutionized by the involvement of nanotechnology. Forms of drug administration include by inhalation, injection, via a cutaneous or transdermal route, and oral administration. Each form of administration requires the movement of the drug into the capillaries, and so, a priority is to ensure that the drug molecules are small enough to be able to pass into the bloodstream. We can look in a little more detail at the different forms of drug administration, to see how nanotechnology could be used to improve current administration methods.

Inhalation - The molecules of a drug to be inhaled need to be small, so that they can pass into the lungs and into the bloodstream, through the trachea. More of the drug is absorbed if the molecules are smaller, as they can move deeper into the lungs.

Injection - An injected drug can move into the bloodstream and take effect relatively quickly, especially if an intravenous route is taken so the drug moves into the bloodstream straight away. Even though a precise, rapid dose is administered with the intravenous route, the disadvantage is that any effect of the drug usually lasts for a shorter time.

Cutaneous - The drug is used to treat external skin disorders, such as skin infections, and so is just applied to the skin, often in the form of a cream or ointment. This form of administration is used if there is a local area on the surface of the skin where the effects of the drug are desired.

Transdermal - To give a drug using this form of administration, a patch can be used, and the drug molecules then penetrate the skin and move into the bloodstream. A steady, continuous dose of the drug is released and passed into the bloodstream. However, a disadvantage is how quickly the drug molecules of the patch enter the bloodstream, as this depends on the ability of the the drug to penetrate the skin in the first place.

Oral - Administration of a drug via the oral route is often used as this method is quite simple to carry out, and should not cause many problems. However, as the drug passes through the digestive system, it may become affected by the natural processes of digestion of the body. However, in some cases, the drug itself can be digested which means that the drug will not be absorbed into the bloodstream, and so will not be effective. Also, as the drug has to pass through much of the digestive system before it is absorbed into the bloodstream, the actual absorption of the drug will take some time.

From looking at all of these existing forms of administration of drugs, the advantages, and disadvantages, should be considered carefully, so that we can find ways to exploit the advantages and ways to overcome the disadvantages. By first recognizing what the properties of a successful form of drug administration should be, the delivery system can then be tailored to meet more specific requirements. This is where nanotechnology comes in and begins to make a huge impact.

Nanotechnology can affect almost all routes of drug administration. For example, when using injections as the form of administration, nanotechnology is used to manipulate dosage so that they can be administered more easily. With oral administration, the form of administration which is still the preferred route even when nanotechnology is applied to other drug delivery systems, nano-enhanced drugs may be given in slow-release tablets or capsules. Stable organic compounds called hydrogels contribute to the formation of nanosphere carriers, a concept ,researched at the University of Texas at Austin, of using nanospheres in oral administration. In transdermal administration, it is now being suggested that electronics could be incorporated into 'patch-like' platforms, which would further aid treatment as it will be possible to monitor the state of the patient through this new type of patch, so we will now be aware of the effects and results, if there are any, that a particular drug is causing. Also, the rate at which diffusion of the drug molecules occurs can also be increased by the involvement of nanotechnology, mostly due to being able to reduce the size of the actual molecules involved.

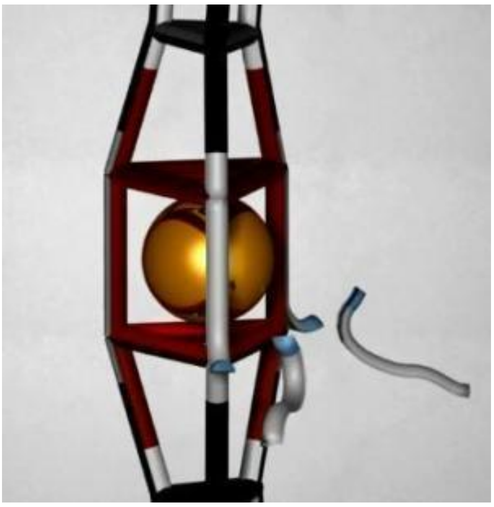

figure 3

So far, only the development of existing methods of administration with nanotechnology have been discussed, but in fact the list of new concepts relating to drug delivery systems is extensive. One approach is the use of 'smart' nanotubes to deliver the drug to a specific area of the body. It has also been suggested that further development of nanotubes, involving DNA nanotechnology, could even be used to target specific diseased cells, where the drug is delivered directly. To form the DNA nanotubes, the method normally consists of manipulating a sheet of DNA to obtain the desired cylindrical shape. However, now, Dr. Hanadi Sleiman and a team of researchers have found a method to form nanotubes of any shape, which can even be designed to be permeable or impermeable. Figure 3 shows an example of a DNA nanotube designed by the researchers, with the encapsulated drug cargo.

Drug delivery systems involving nanotechnology could be used to treat cancer as well as infectious disease, and so the use of nanotubes, more specifically DNA nanotubes, is be a strong possibility for the future. Another concept that is in development is the delivery of chemotherapy drugs by nanoparticles, straight to the cancer cells. Drug delivery in this way, to only the diseased cells, greatly reduces any adverse affects a drug can have on a patient, as healthy cells would have been damaged or destroyed during the process of trying to destroy the diseased cells. Nowadays, not only is the treatment of cancer by using nanotechnology being considered, but so is the treatment of Schizophrenia, HIV/AIDS and Alzheimer's disease, as there is now more research into drug delivery based on nanotechnology for these diseases.

Once the nanoparticles have been delivered to the desired location in the body, the next obstacle to be faced might be to ensure that the particles remain in that location so that the drug can work effectively. An example of where this problem arises is with the presence of a mucus lining, such as in the nose, so it is very likely that the nanoparticles will simply be 'swept away' in the mucus. A solution to this is the development of nanoparticles which bind strongly to cells, similar to how the burrs of a plant attach themselves to fur on animals, for example, which is yet another instance where nature has inspired and influenced nanotechnology. The nanoparticles are made up of glass beads and nanowires, and the beads enable the binding to cells, a concept researched by a team led by Tejal Desai in the University of California - San Francisco.

Another new notion is the use of a microscopic 'cannon' to 'fire' nanoparticles to where they are needed. This method may be used if the nanoparticles need to pass through tissue that is quite thick, because after firing, the nanoparticles can travel up to almost 800 times faster than they would if there were in solution, an idea investigated by Stefaan De Smedt and a team in Ghent University in Belgium.

Ethical Issues

However, as with many new conceptions and developments, there are ethical issues and concerns with the use of nanotechnology in medicine. One matter is when the size of nanoparticles becomes a danger rather than an advantage. Some people believe that nanoparticles may be small enough to be able to pass through the blood-brain barrier, which could result in poisoning. There is also the issue of introducing artificial objects into our bodies, particularly as the science of nanotechnology is developing rapidly so more uses of nanotechnology are being discovered and used in the body. Many people feel uncomfortable having foreign articles such as these in the body, and may see this as unnatural. Some people are more concerned with the fact that nanotechnology is still quite a new discovery when compared to other sciences and other techniques in medicine, yet we are trying to apply nanotechnology to as many areas as possible, perhaps without knowing or understanding the full, long-terms effects that the application of nanoscience brings.

CONCLUSION

Nanotechnology is a relatively new science, and although we may still be at a comparatively early stage in the development of nanotechnology, the possibilities we think nanotechnology is capable of are great. Not only has nanotechnology already altered the way we currently administer drugs, but it has brought completely new concepts to drug delivery systems, and revolutionized the methods we will be using for the administration of drugs in the future. I feel that with further development and more information about nanotechnology and the life-changing benefits that it brings to us, some of the fears and ethical issues that people may have will be alleviated. The range of techniques and advancements nanotechnology has contributed to drug delivery systems alone is far greater in comparison than the few concepts described in this paper, and this range will only continue to increase and diversify. I also believe that as we carry out more research and investigations into how we can use nanotechnology, we will be able to use this science more effectively and generate the outcome we desire when seeking to treat a patient.

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