

The Role of Nanotechnology
In Drug Delivery Systems

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RESEARCH PAPER

BASED ON

PATHOLOGY LECTURES

AT MEDLINK 2010

Abstract

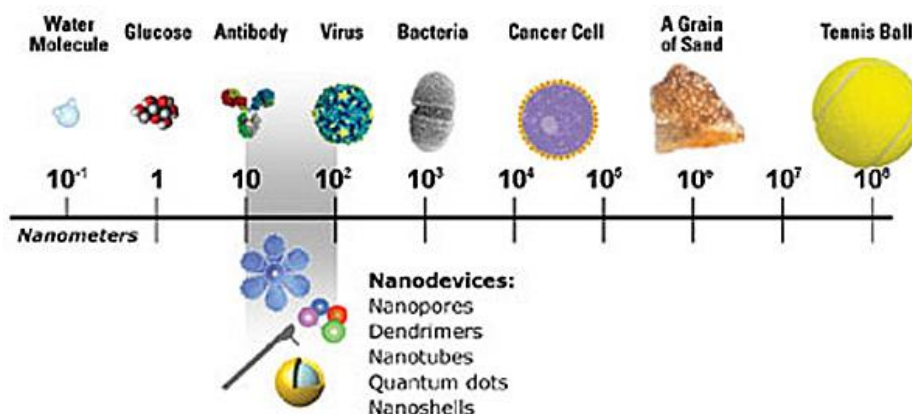
Due to the molecular scale which nanomaterials work at, nanoparticles have the ability to revolutionise drug delivery systems. As a result of many current complications with regards to gene and drug delivery in medicine nanotechnology has gained tremendous interest over recent years as a solution to many of the complications faced today. Nanoparticles provide a massive weight reduction along with stability which improves the overall efficiency of drug delivery systems and allows for fewer complications to occur. These properties of nanoparticles is what has helped nanotechnology gain interest over the years and the reason why nanotechnology is threatening to eradicate old methods of drug delivery systems and replace them with nanotechnology based delivery systems.

Introduction

Nanotechnology is the manipulation of particles on the nanometer scale as shown in Fig.1. The term nanomedicine is the use of this technology for health care and medical purposes. Generally, nanotechnology tends to be split up into two different sectors. The first: “bottom up” is the manufacturing of devices at molecular level. The second: “top down” is the use of large devices to manufacture structures at molecular level.

Nanotechnology has gained interest over recent years as it allows current medical treatments to become less expensive with fewer complications. As demonstrated by the work of Chiranjib, R.Margret 2009, nanotechnology allows advancements to be made which are much beyond the medical knowledge of today, such as constructing surgical instruments which are precise enough to operate on cells. Nanotechnology is often considered as the future to current therapeutic and health products currently being used.

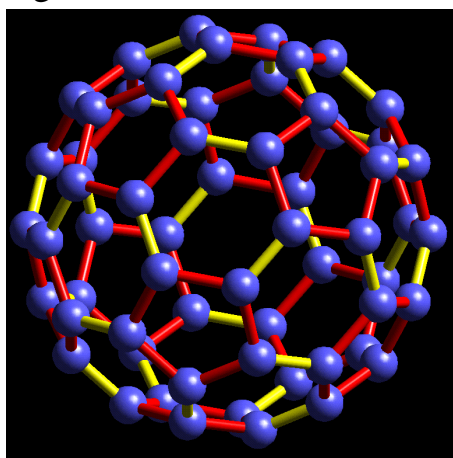
Fig.1.



The molecular scale of nanoparticles makes them useful in drug delivery systems for many reasons. One reason is that because of their size, these nanomaterials have a very large surface area which increases the efficiency of delivering drugs. Also, due to these particles' size only the target area can be exposed to the nanoparticles. This means that nanoparticles can still be used in the detection or treatment of diseases without exposing healthy cells and tissue to them. In addition, as a result to their size nanoparticles have the ability to avoid many of the bodies' natural defence systems. Drugs are also given better solubility which similarly leads to better absorption which allows patients' to maximise the uptake of the drug. Recent developments have seen the first nanotechnology drug delivery system being used, which was used to tackle cancers. Nanoparticles are also ideal for the use in drug delivery system as they dramatically improve the uptake of what before their intervention were poorly soluble drugs. These nanoparticles can be used as an imaging agent also, allowing doctors to track any developments that take place within the cancer cell. This method of tackling cancer increases efficiency treatments to cancers in a late phase and therefore increases patients' chances of survival. Apart from nanoparticles size there are many other properties which allow them to become effective drug delivery systems. These include their ability to reduce drug toxicity and their ability to control the time release of a drug. Current drug delivery systems which include nanoparticles include "Buminstfullerene" or "bucky balls". These are very stable and effective dome-shaped structures, as shown in figure 2. Due to their stability this allows an active drug to be attached to these structures then transported to a target tissue.

Nanotechnology although can be risky and potentially detrimental if not used properly can provide effective treatments without many side-effects. In addition nanotechnology in the form of nanomedicine can be used effectively and efficiently to cure disease and also repair damaged tissue.

Fig.2

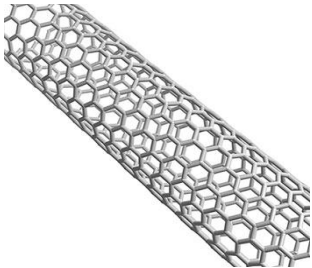


The role of nanotechnology within medicine stretches much further. Other examples of nanotechnology in health care include; nanosilver particles being used for their antimicrobial

properties as wound dressings, nanosensors for diagnostics, magnetic resonance imaging and bone substitution.

The use of nanotechnology in medicine is not only limited to disease. Nanotechnology can also be used in bone repair. Nanotubes, as shown in figure.3 can be used to form a new structure allowing new bone to grow.

Figure.3



Nanoparticles as well as the treatment of disease can also be used in diagnostic medicine by attaching themselves to infected cells, this allows the doctor to then investigate these infected cells in a blood sample and make a diagnosis.

Machines using nanotechnology can be used to repair damaged cells or tissues with the aid of surgery. These machines are able to sense that cells or tissues are damaged then adapt these to repair them back to a functioning state.

Nanotechnology has also begun to play a part in the diagnosis and treatments of disease. Microchips which are coated with human molecules are inserted into the body and then emit electrical impulses on the detection of disease.

Similar to cancer nanoparticles have been used to tackle tumours. When encountering tumours these particles proceed to emit a magnetic field which obliterate the tumour and minimize the possible damaging effect of the tumour.

Nanotechnology has also began to be paired with another new method of “smart drugs”, these smart drugs carried by nanoparticles to the given area of distress. This method of administration is more efficient and supposed to have much better results than normal methods of administering drugs.

Discussion

The current method for drug delivery systems is mostly through an intravenous injection; however, this has its danger as it becomes more susceptible to medical attack. However, in the case of using nanotechnology for drug delivery systems the drug in question is prevented from coming into contact with the transport medium, this prevents the transport medium from affecting the drug and therefore makes the drug delivery more effective and with fewer complications. This method of drug delivery also allows specific cells to be targeted.

During the use of nanotechnology in drug delivery the nanoparticles can be controlled by a magnetic field this allows for the easy mobility of the drug and this way of treatment will

reduce the overall side effects experienced by the patient as only the target area would be exposed to the drug.

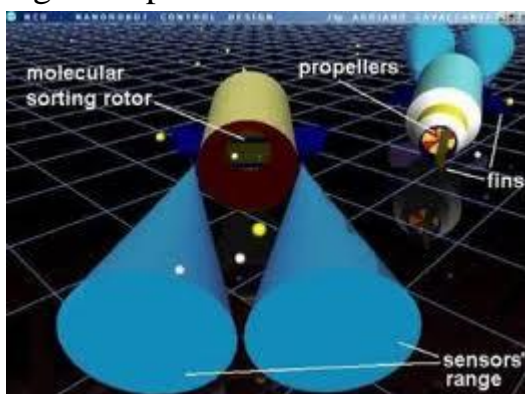
Nanotubes can also be regarded as another nanotechnological drug delivery system. Their structure allows these nanotubes to carry the drug until they reach an area of stress before “injecting” the given drug into the damaged area. This method of drug delivery has many different advantages linked with it. One of which is due to its method of administering drugs these nanoparticles will be able to release the drugs directly on the suffering area. This therefore means that the overall administration is more efficient so less dosage of the drug would be required so the patient will be less at risk of suffering side effects. Also due to these particles unique size they can be incorporated and carried in the blood-stream.

Another method in which nanotechnology has aided drug delivery systems is through Micro Electro Mechanical System. These mechanisms work by detecting changes in the blood then automatically administering the correct dosage in order to counteract these changes. The advantages to using this system for blood delivery is that there is no unnecessary extra exposure to drugs, only the required out needed to counteract the changes taking place in the body will be released.

The use of nanotechnology in drug delivery systems has also brought about significant changes to diabetics. “Nano-pumps” provide an alternative to the standard insulin injections. These pumps allowed the user to adjust their own dosage of insulin at any given time. However, these pumps are expensive and many doctors believe are more detrimental to a diabetic’s health than the standard insulin injections.

In the case of diseases such as Alzheimer’s and cancer nanotechnology can also play a vital role. Nanorobots shown in figure.4 have the ability to bring vital proteins to target areas in order to initiate drug delivery system.

Figure.4. potential Nanorobot



Negative aspects with the use of Nanotechnology in Medicine

Despite the many advantageous aspects to the use of nanomaterials in medicine there are also many negative aspects with regard to the use of nanotechnology in health care. One of which being due to the research and implementation of nanotechnology in health care being relatively new, many of the future implications of exposure to these materials is still not

known. It is this grey area within the use of nanotechnology which causes many health care workers to be sceptical over their use. The size of nanomaterials also raises many concerns when discussing their use as their size allows them to enter the human body through many routes which include:

- dermal
- inhalation
- ingestion
- injection

The fact that humans can be exposed to these particles in many different ways raises concerns about the use of them in health care.

There have also been many reports claiming that manufacturing materials of the size of nanomaterials will increase their toxicity as opposed to regular materials. Other issues to do with the use of nanomaterials in medicine is that as a result of their ability to hinder biological process it is often perceived that they are intervening with nature. Furthermore during the manufacture of nanomaterials many waste products are formed, these waste products can then penetrate skin and cause harm.

Despite the obvious advantages of the use of nanotechnology in medicine it because of these negative aspects the use should always be considered carefully before applying in any case.

As well as the social and environmental concerns linked with the use of nanotechnology there are also many ethical concerns. One of which is that due to importance and many advantages to new developments in nanotechnology it has the ability to cause conflicts between different countries.

Future of Nanotechnology in Medicine

The future of nanotechnology in medicine is truly endless given the correct research. Nanotechnology has already helped to develop and improve many areas currently in medicine and with the correct research it is possible that it may go on to tackle diseases such as respiratory and heart disease. It is also possible that nanotechnology may develop enough to help tackle fertility problems and also in the reparation of human senses. Although many of these developments will tackle ethical issues such as the argument that nanotechnology should not be used to intervene with nature.

Certainly it is possible for nanotechnology to expand further into health care and enter dentistry with the ability to develop new more efficient procedures. Nanomaterials will make it possible if used properly to maintain near to perfect oral health, and will improve the ability to provide high quality dental care to the world. As a result of this care will help to reduce many diseases currently associated with dentistry such as gum disease.

Cardiac problems are currently one of the leading causes of mortality. Nanotechnology if developed further threatens to change this. Current research has already made it possible to open blocked arteries through the use of nanotechnology by using smaller less bulky

instruments which are not prone to disease. In future years nanotechnology can be used to investigate certain cardiac components which may be the causes of cardiac disease. This will help doctors making early diagnoses.

The future of nanotechnology with regards to the diagnostic medicine is potentially revolutionary. If medical diagnostic tools were to be exposed to nanotechnology and undergo a process of “miniaturisation” then this would allow these tools to sense even the slightest abnormality in the human body which before may have gone undetected. This early diagnosis can then lead to a more effective and efficient treatment increasing the patient’s chances of survival against this abnormality.

Currently in orthopaedic medicine there is a problem to do with skeletal disorders. One of the reasons for this is that many implants tend to fail once placed in the body. It is possible that with nanomaterials this problem can be solved as nanomaterials contain all the right properties to allow them to be biocompatible with bones and therefore help to aid their healing. Carbon nanotubes provide another way in which nanotechnology can help improve current orthopaedics. As a result of the similarities in structure with these carbon nanotubes and collagen which is found in bones it is certainly possible for these nanotubes to replace collagen. This can help in bone fractures and also bone alignment.

In addition, nanotechnology can also play a further role in surgery. Nanoshells (figure.5) can be used to stitch up arteries which have been accidentally cut during perhaps a transplant, these can be used to weld the artery preventing bleeding out and therefore reducing the complications to do with surgery. Another use of these nanoshells is in the treatment of cancer. These shells are composed of silica and gold. These nanoshells allow light to be concentrated and converted into infrared radiation. The frequencies in which these nanoshells work at can also be altered through tampering with the thickness of gold. This treatment only damages the cancerous cells and does not harm healthy cells and tissues.

Figure.5.



Nanotechnology’s ability to repair nerve damage also makes it ideally suited to tackle diseases such as Parkinson’s. Nanomaterials are simply injected into an area experiencing nerve damage and regeneration of these nerves is observed, although this method does contain some complications.

Currently the dyeing of cells is scientist current method of tracking. However, nanotechnology may allow for a different method using “quantum dots” this method will be much more efficient and effective than the current dyeing method. These dots are capable

of emitting all colours of the visible spectrum and can absorb light of any wavelength. These dots can then be used to tag specific proteins to follow and monitor their progress. If this method were to be developed further then it would be possible for these quantum dots not only to track cells but also to inject them with drugs combating infected or diseased cells.

Developments in nanotechnology can even help to combat neurological diseases. Through the use of nanowires, the activity of individual neurons can be observed and monitored. This can be crucial to obtaining more information regarding the brain and also helping to find new cures of neurological diseases as more would be understood regarding interactions between different neurons. Recently these nanowire probes have allowed signals from different parts of the same cells to be recorded. If this were to be developed further then it can lead to greater knowledge regarding how exactly the brain, muscle and heart function and communicate,

Furthermore some scientist have developed theory that in the future nanotechnology can be the key for developing an anti-ageing cure, this theory however has been met by many critics and large amounts of scepticism.

There are many problems associated with my ideas in the use of nanotechnology in health care in the future. The fact that nanotechnology is still relatively new is a big issue when considering developing its use in health care as its long term effects are still unknown. As well as this, other problems with my ideas include the fact that many of my ideas have not been tested so the side effects are unknown. For example, what happens to the “buckyball” after the drug is administered is still a mystery and it is unknown whether this can have a detrimental effect on the body. In addition, nanomaterials being used in surgical equipment will prove expensive these materials are very hard and tough so moulding them into the correct shape in order to manufacture tools will prove quite difficult. Also, in general until the mass production of nanotechnology particles is established any developments this sector will prove very expensive.

Conclusion

In conclusion I believe that it is clear that despite the numerous negative aspects to do with the use of nanotechnology, I believe that the benefits strongly outweigh these negatives.

Nanotechnology provides new more effective and cheaper methods which are threatening to eradicate old less effective ones. In the case of drug delivery systems nanotechnology is allowing more effective procedures to take place only targeting affected areas and not damaging healthy tissue. In addition, the use of nanotechnology in cancer is proving to me incredibly useful in the diagnostic and also treatment of cancer.

Nanotechnology provides a much better way of administering chemotherapy to patients. Diseases such as Alzheimer’s and diabetes are also made more manageable with the aid of nanotechnology. Nanotechnology also has the ability to improve overall patient care by

providing treatments which prevent unnecessary surgery taking place. On a whole drug treatments will be improved with the aid of nanotechnology as nanodevies provide an increase in bioavailability of drugs.

Furthermore despite the negatives aspects associated with nanotechnology with the correct research the possibilities of nanotechnology in medicine are endless. However, I believe that in the future once the long term effects of the use of nanotechnology is known and the effectiveness is proved then this should help to eradicate doubts of using nanotechnology. With the right research nanotechnology can be used to tackle many issues which have hindered humans such as cancers and also helping to repair fertility tissues.

Despite many obstacles threatening to hinder the development of nanotechnology in medicine I believe that the potential to revolutionise medicine will outweigh the critics nanotechnology will be used frequently in hospitals around in the world in the next couple of decades.

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