

Who knew the answer would be so close to home?

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Abstract

Nanotechnology is quickly revolutionising the modern world with its unique and unmatched advantages. This paper investigates how these advantages could be utilized for medical treatments, specifically the treatment of cardiovascular disease. Not only is it potentially fatal, in 2006 cardiovascular disease alone cost the NHS £29 billion a year, and recent trends suggest that the figure is only going to increase. This makes it more vital than ever that new and effective treatments are found.

Introduction

For thousands of years mankind has marvelled at the universe, looking deeper and deeper into space to find answers to help develop mankind to new highs. But perhaps the answer is closer to home, hidden within the very atoms we're made of, on a scale so spectacularly small. Nanotechnology, a recent discovery, will change the way we live forever. It has allowed us to manipulate singular atoms to a scale of a billionth of a metre (10^{-9}). By cleverly engineering the atoms in this way their properties are altered, due to a significant change in the surface area to mass ratio. On a nano scale, atoms have many advantages including being more chemically reactive, stronger, better conductors and many other enhanced physical properties. The most obvious advantage is the size. Nanotechnology allows machines to be created on an incredibly small scale in comparison to what has previously been possible. This means machines can be used in smaller areas and for much more precise tasks, two appealing characteristics when considering medical treatment.

Nanotechnology was first thought up by Richard Feynman, who initially suggested the idea in his speech 'There's Plenty of Room at the Bottom' in 1959. From this other professors expanded on his idea, Norio Taniguchi, a professor from the Science University of Tokyo wrote a paper in 1974 defining the word Nanotechnology as mainly consisting of the separation, processing, consolidation and deformation of materials by one atom or molecule. In 1981, a titanic breakthrough in nanotechnology occurred when the scanning tunnelling microscope was invented. It allowed scientists, for the first time ever, to visualize the position of individual atoms. Next in 1989 scientists at IBM found a way of using the microscope to move individual atoms. This advance caused a rise of interest in nanotechnology, with companies using the technology to improve their consumer products. By the end of the 1990's they were being used in the commercial market.

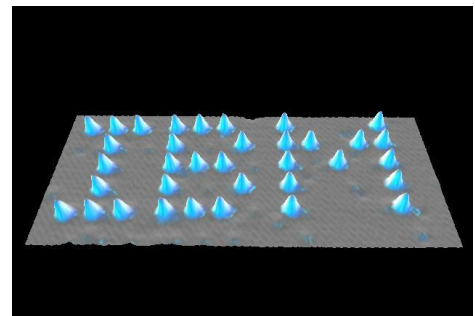
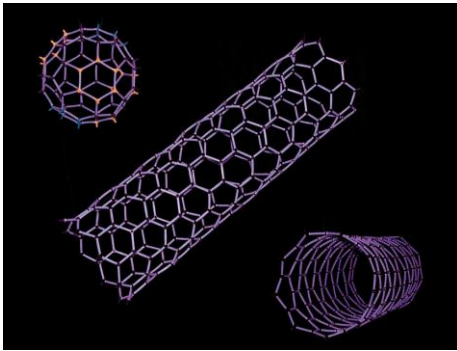


Figure 1 The IBM logo created by nanotechnology.

Despite nanotechnology being a new concept to the scientific world, people were quickly realising its potential. It didn't take long until the advantages of nanotechnology were being harnessed for medical purposes. Carbon nanotubes are tiny carbon cylinders, that are hollow with a diameter 10,000 times smaller than that of a human hair! These nanotubes are extraordinarily strong and can be structured to be highly effective electrical conductors.

Figure 2 Examples of Carbon Nanotubes.



This clever tubing can be manipulated for a number of different uses. There is potential to develop the carbon nanotubes to help the human body to transmit nerve signals in areas that suffered large nerve damage from a serious trauma. This development could improve patients' lives who suffer amputations because nanotubes are very good at conducting and thin films of carbon nanotube can serve as a surface to grow cells and so can be used as an electrical interface between living tissue and prosthetic devices. This would allow the patient to control their own prosthetic limb, like part of the body.

Despite nanotubes being extremely effective and useful, they aren't nearly as exciting as other potential advancements. Nanorobots will be the face of the future. Tiny robots able to perform the most precise of tasks, overcoming so many medical obstacles that have stopped countless other treatments in their tracks. They could be an effective method to treat cancer. For example, one problem with chemotherapy is that it kills many non cancerous cells, but it has been suggested that in the future nanorobots could administer chemotherapy drugs directly to the tumour, without affecting the bodies' healthy cells.

Another type of nanotechnology which has been discovered is a nanochip. A nanochip can monitor the bodies chemical levels and attempt to balance them if they are incorrect. This will be beneficial to diabetics as their blood sugar levels could be monitored precisely and when the level is too high, insulin could automatically be released, to ensure the levels are balanced at all times. This would be a far less inconvenient treatment for diabetics.

Discussion

Cardiovascular disease is one of the world's largest killers claiming 17.1 million lives a year worldwide; making it vital we exploit the wide range of opportunities presented by nanotechnology to help treat heart disease. There are different types of cardiovascular disease, each needing different types of treatments so calling upon the different advantages of nanotechnology. These include Coronary heart disease (heart attacks and angina) and strokes. These are dangerous, potentially fatal conditions, and can appear in just a matter of minutes. There are multiple contributing factors which cause these dangerous conditions to occur, and nanotechnology could solve these factors before they develop enough to cause these conditions to arise. The main cause of cardiovascular disease is the formation of atheromas (a build up of plaque on the artery wall) which can cause atherosclerosis. These are mainly

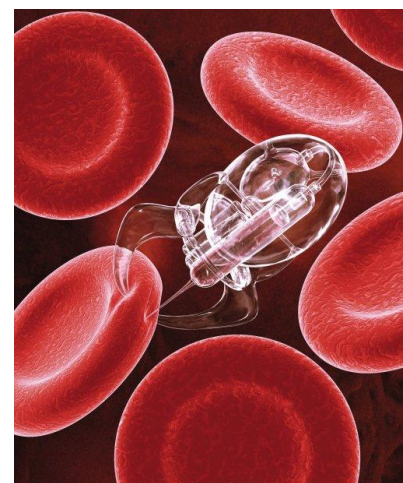


Figure 3 A Nanorobot attaching itself to a red blood cell.

caused by high blood pressure and high cholesterol levels. Heart attacks and strokes occur as a consequence and if not treated urgently it can start to cause heart tissue to die.

Nanorobots have the most potential to shape the future of medicine as they could be used in a diverse range of tasks. These nanorobots could be placed within our bodies set to do certain jobs. It has been predicted that these resourceful robots could help break down atheromas and break up blood clots which are the main cause of most heart attacks or strokes.

Atherosclerosis is the formation of atheromas, these are caused by high blood pressure putting too much strain on an artery, causing an lesion. This then damages the endothelium which causes fatty streaks or plaques to form. These plaques attract white blood cells to the damaged area. An atheroma is formed by the build up of cholesterol, scar tissue, smooth muscle and platelets. This narrows the artery's lumen and hardens the wall, blood pressure then increases to pump the blood through this narrowing. At the site of the atheroma, the rough surface causes the platelets to swell, projections form on the outside of them. This causes them to burst thromboplastin, thus causing a chain reaction leading to the breakdown of fibrinogen to fibrin. Restricting blood to this area of the body causes the tissue to die from lack of oxygen and other materials such as glucose which are carried by the blood. Scientists involved with nanorobots believe that a nanorobot can be developed which is inserted into the blood stream where the atheroma has occurred and cut away at the plaque so that the artery lumen begins to widen again. This could be a significant discovery for people at risk of a heart attack or stroke, because these robots could be given to reduce their atheromas, reducing their blood pressure and so reducing the chance of the conditions leading to anything more serious. This procedure could be done without much trauma or stress to the patient as no surgical operation is needed.

Another use of these ingenious robots is in the breaking down of blood clots. Blood clots can occur from atheromas or the slowing of the blood through veins from long time periods of sitting or lying down. The clots can restrict the amount of blood being received from a certain area of the body and are very serious if left. A blood clot is formed from fibrinogen being broken down; the fibrin is insoluble and acts like a mesh, collecting the red blood cells. Nanorobots could be inserted into the blood stream and travel to the clot to break it up. For this to be possible, the robot must be small enough to not cause a block in the bloodstream itself, and therefore compounding the existing medical condition.



Figure 4 showing a nanorobot breaking down a blood clot.

A further solution to the common life threatening disease would be to use nanorobots to monitor the atheromas in atherosclerosis so treatment can be given sooner, when signs suggest the patient is at risk. Strong evidence that shows that this can be done comes from Georgia Tech and Emory University who received a five-year \$14.6 million contract from the

National Institutes of Health (NIH) to continue the development of nanotechnology and bio molecular engineering tools for methodologies in detecting and treating atherosclerosis. With this research, they have found that early stages of cardiovascular disease can be detected, using nanoparticle, magnetic resonance imaging (MRI) probes, through in vitro and in vivo, to collect images of the plaques from atheromas. Also, more research is going into the detection of atherosclerosis from blood sampling, measuring the presence of specific micro-RNA's. Although this seems technical, this diagnostic approach is predicted to be fast, inexpensive and non-toxic.

Nanotechnology could also solve the use of drugs found to treat cardiovascular disease. The drugs nature has made them difficult to be administered because they are water repellent and have a short half life. However, drug delivery could use nanoparticles to carry the small molecules into the body; this system could optimize circulation time and reduce toxicity. This method would not only solve the problems associated in drug delivery for cardiovascular disease but also, could solve the problems which occur with drug delivery in all areas of medicine. For example chemotherapy treatment for cancer could be delivered to just the area of the tumour, rather than the whole body. This would cause fewer adverse symptoms during treatment.

Patients who have suffered a heart attack or stroke from cardiovascular disease usually have damage to the heart, as the lack of oxygen, has caused the cardiac muscle cells to die. Scientists are looking into how stem cells from bone marrow can be changed to cardiac muscle cells to help repair the heart. Although adult stem cells, found in the bone marrow, can generate into different cell types, they are limited. Whereas it has been found that embryonic stem cells are not limited; however there are ethical issues which arise when you consider using them. This means that if nanotechnology had the power to edit adult stem cells so they could generate cardiac muscle cells, it would have a tremendous impact on modern medicine. It would allow patients who have lost cardiac muscle from a heart attack to regain strength back to the heart, so increasing the ability of the heart to pump blood around the body, without the need of embryonic cells.

This would not just improve the lives of heart attack sufferers but the lives of patients who suffer from Septal defect (a hole in the heart). It could be used to grow new heart muscle to repair the hole; the heart would then function normally with an excellent long term prognosis.

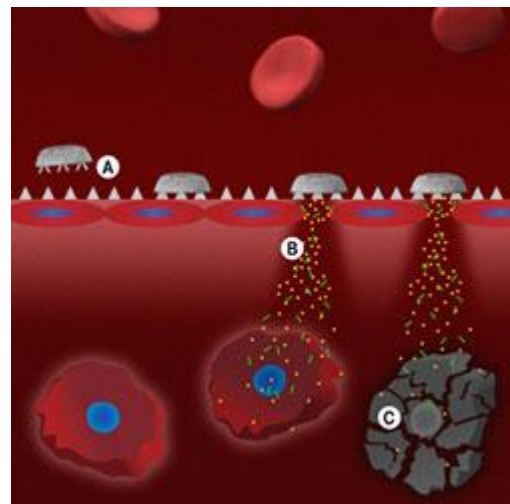


Figure 5 showing a type of drug delivery involving nanotechnology.

Although, the medical predictions scientists are making on how nanotechnology could change the earth are exciting, there are many ethical issues arising over the uses of them in medicine. As Peter singer wrote in his paper 'Mind the Gap: Science and ethics in nanotechnology', 'the science leaps ahead, the ethics lags behind'. For many people Nanotechnology is a very un-clear topic because of its quick arrival, and so the prospect of using this technology for medicine is daunting. The fast pace at which it is being developed has brought many people to ask the question of whether nanotechnology is safe to be used, although, it is already being used in consumer products such as sunscreen. The main ethical issues are whether nanoparticles are toxic to the body and could do more harm than good. If using such unnatural objects in the body is right and whether handling atoms on an individual scale is wrong and 'playing god'? For ethical issues it is important to outline the benefits and disadvantages of nanotechnology. Some of the ethical problems can be solved simply by testing the technology out more before using it in medicine; other ethical questions will not be as easy. Educating the public would allow everyone to understand the issues with nanotechnology, to have an informed opinion; this would allow questions of safety and the uses of nanotechnology to be answered. Overall, it will be hard to overcome the ethical dilemmas; however there are issues in many areas of science and medicine, as long as the technology is deemed safe and ethically acceptable it should be allowed to be used. The dangers which may be faced are the uses of nanotechnology for weaponry and misuse; this is why the government are considering bringing in new laws on the handling of nanotechnology.

Conclusion

This paper has looked into how nanotechnology could potentially decrease the death toll due to cardiovascular disease and reduce the amount of heart attacks and strokes which atherosclerosis causes. This would be very beneficial for the medical world and could help deal with the emerging factors which a modern lifestyle has caused. However, nanotechnology will not just help cardiovascular disease; it will solve problems for all kinds of diseases and medical conditions. Not only will it help cure disease, it will ease financial pressure on the NHS due to less people suffering from the disease, allowing them to invest resources elsewhere.

I believe nanorobots will have the largest impact on medicine in the future because of the vast range of problems it could be used to solve. For example, for cancer, nanorobots could kill the cancer cells and emit radiotherapy on the certain area without affecting any other cells in the body.

It has become apparent when doing this research that Nanotechnology could make a massive impact on medicine and how the treatments we use are delivered. It could solve some of the most common and dangerous life threatening diseases we face. There are endless possibilities when engineering to a nanotechnology scale, it really could be the answer to all medical problems.

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