How Nanotechnology Can Be Used To Treat Heart Disease, Diabetes And Cancer?

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PASS

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Abstract

The reasons we chose to research the use of nanotechnology in treating heart disease, diabetes, fertility and the brain is because one of our researchers suffers from diabetes. In addition learning about nanotechnology in our education has increased our interest on the subject. The aim of this paper is to explore how Nanotechnology was developed and the intended uses for nanotechnology in the world of Medicine. This will help us to investigate the central idea of this paper, which is to present how nanotechnology is being produced and used in the treatment of heart disease, diabetes, fertility problems and the brain. We hope to conclude from this paper that the development of Nanotechnology will greatly increase advancements in medical treatment and hopefully lead to cures for many of the ailments we suffer from today.

Introduction

Nanotechnology is the development and manufacturing of technology at a scale of a nanometre – 1×10^{-9}. Nanotechnology is present in many parts of industry and medicine and the impact that nanotechnology is having on modern day life is growing with every year that passes. The synthesis of nanomaterials is one of the most active areas of research in nanotechnology (http://www.idb.hr/diabetologia/05no4-1.pdf). Nanomaterials can be created by massively parallel self-assembly. This technology is needed for molecular and atomic control of the building materials. Nanoscale manufacturing involves mechanics, electrical engineering, physics, chemistry, biology, and biomedical engineering. The future view of nano-manufacturing is the combination of engineering, science and biology. Nanotechnology is relevant to the advancement of Medicine because of the many ways it can be used to advance the treatment of patients.

Nanomaterials are important in medicine because they can be used in the creation of artificial organs such as the heart and the pancreas. This is a very important future development because it will help to increase the quality of life for patients and could be a cure for diseases such as diabetes. The reason manufacturing like this is important is because it is capable of producing artificial organs of the right size to be implanted in to the body via injection of beta cells or surgery. Research in the field of nanotechnology about the biological toxicity of nanomaterials has shown that there is a chance that the body's immune system could be triggered as nanomaterials are seen as a foreign material. This can be combated by the use of immunosuppressant's and the overall benefit of the use of artificial organs made from nanomaterials could be seen as important in treating certain diseases and the advancements in medicine might also be capable of dealing with the immune response.

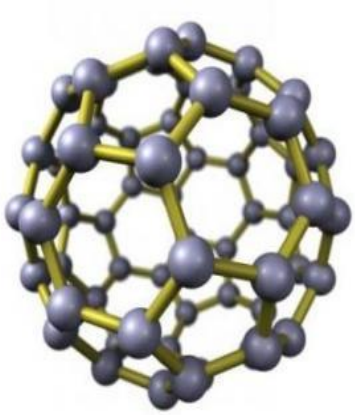


Figure 1

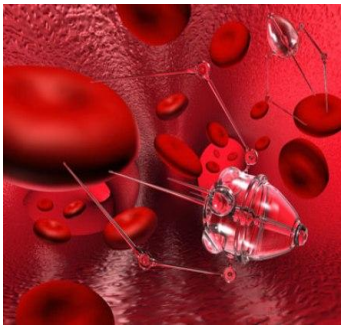
One of the most recent advancements in nanotechnology is the use of Buckminsterfullerene balls (Bucky Balls). Here is an image of a Bucky ball (Figure 1). They are used to transport drugs around the body and protect the drugs until they reach the specific part of the body they are required for and are released. The buckminsterfullerene is a carbon based molecule so the structure forms a protective casing around the drug. Drugs are implanted into the ball and it is broken down once it has reached the area in which it is required. All of these advancements in the use of nanotechnology in medicine are important in future for uses such as curing cancer and diabetes and heart problems and fertility. We will go into a lot of detail about these developments in the next part of our paper.

Diabetes

The research of Nanotechnology has provided and is developing new ways of treating diabetes. Diabetes is an increasing problem in the United Kingdom. Around 150 million people suffer from diabetes in the world. It has been predicted that this number will be doubled within 15 years. Type 2 diabetes accounts for about 85% of all cases with diabetes. This shows that this is an increasing problem in the modern world and the advancements in treating diabetes are becoming more important as more people are diagnosed with this illness. Nanotechnology can advance the treatment of diabetes in many ways. Nanotechnology has achieved the status as one of the critical research endeavours of the early 21st century. The use of nanomaterials in treating diabetes is mainly restricted to only a few areas at present:

The use of sterile needles: the use of nanomaterials to coat needles forms antibacterial properties in the needles, useful in the self-monitoring of blood glucose levels. The use of TiO2 to coat needles and lancets by annealing has produced antibacterial properties and therefore helps to sterilise and stop the spread of disease when using needles.

The use of nonomaterials to deliver drugs to specific parts of the body: this would be an important development in the world of medicine as it would help to treat many other diseases other than diabetes. Chitosin nanoparticles would be used to deliver insulin to certain parts of the body. This idea was put forward by Zengshuan Ma et al. This could also be used to treat problems with other organs like the kidney or the heart as it could transport the required medicine to the correct part of the body.



http://www.online-diabetes-information.c 1

Another use for nanomaterials in the treatment of diabetes is the creation of materials that respond to glucose levels in the blood by releasing insulin. This would be a better way of delivering insulin into the body without using needles that have a chance of being contaminated. One such system, a polymer comprising covalently bound sugar is cross linked using a multifunctional glucose-binding protein such as one of the plant lectins. When the matrix comes in contact with free glucose in solution, the protein releases polymeric glucose and binds to free glucose molecules, causing the hydrogel to disintegrate. Nanoparticles constructed from such glucose responsive materials might then improve the means of insulin delivery. This is hopefully a future development in the use of nanotechnology in medicine.

A use of nanotechnology that scientists are hoping they will be able to develop in the near future is the use of nanomaterials to create artificial organs like the pancreas that are small enough to be transplanted into the body rather than using machines like Dialysis machines that people have to use when their kidneys have failed. This could prove to be a cure for diabetes but would be costly and could prove to be a risk to the patients' life, especially considering the effect of the artificial organ on a person's immune system.
(http://www.chalcogen.infim.ro/Mishra.pdf)

The Heart

Each year in the USA, a third of the population dies due to heart disease. Much research has been done in to finding possible ways of treating the symptoms of heart disease, and nanotechnology has been proved to work in treating some diseases. It has been known to help treat defective heart valves and detect and treat arterial plaque. (http://www.ncbi.nlm.nih.gov/pubmed/20369034)
Firstly, valves can become too rigid or too soft causing the valve to become floppy. (http://www.understandingnano.com/heart-valve-collagen-gold-nanoparticles.html)
This makes it much harder for the heart to pump blood through to the different chamber of the heart and to the body which increases the blood pressure and could lead to a myocardial infarction. Thanks to the use of nanotechnology we are able make Nanorods which are usually made up of nanomaterials and in most instances are minute gold rods. (http://discoverysedge.mayo.edu/de08-3-biotech-mukho/index.cfm)

Nanorods allow us to alter the structure of valves. Valves are made of collagen which is a fibrous protein often used to connect and to support tissues, for example, internal organs, cartilage and tendons. When there is too much collagen it causes the valve to become rigid restricting smooth blood flow, and if there is an insufficient amount, then it causes the valve to become floppy. When a nanomaterial is mixed with a polymer (a chain of monomers bonded by covalent bonds), it creates a charge. If this charge is added to the collagen it can affect how the protein is structured. This is because collagen production is made by fibroblasts, which is a type of cell which donates stem cells so collagen can be formed. (http://en.wikipedia.org/wiki/Fibroblast)
When the charged nanomaterial comes in to contact the protein it changes to production of collagen by its fibroblasts, causing the phenotype to change. Therefore, the cell loses its normal characteristics and behaviour which can lead to the reduction in production of the fibrous protein. (http://en.wikipedia.org/wiki/Phenotype)

This breakthrough in advanced nanotechnology allows us to stop the formation of unwanted collagen but also with the aid of the correct drug, for example a growth enhancer (steroid) can help produce more collagen if needed. This results in the decrease of valves being inefficient which can cause a poor blood flow, which in turn would increase the blood pressure putting much unnecessary strain on the heart. Therefore, causing a decrease in the amount of myocardial infarctions in the world today, this is a very common cardiovascular disease due to high fat saturated diets. Due to this discovery of combining nanomaterials and polymers, with a sufficiently funded research programme it could lead to further advancements in the future on how to treat other heart diseases. For instance, this technique could be developed to be cheaper by finding out other nanomaterials which could be used instead of gold. Also previously mentioned it could be used to treat other diseases like aneurysm's which can lead to haemorrhages. For example, a drug could be attached to the nanomaterial which will stop the blood bulging in blood vessels.

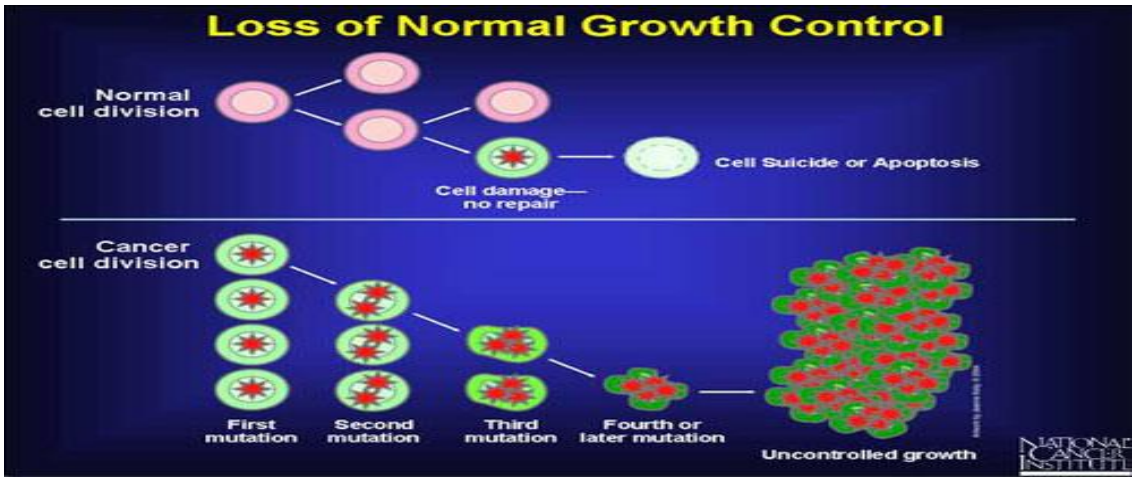
Furthermore, nanotechnology has advanced the treatment of clogged arteries vastly over the last few years. Arteries play a key function of transporting oxygen around the body which is needed to respire and if they are blocked or damaged it could be fatal (http://biology.about.com/b/2009/07/10/artery-function.htm). Blocked arteries are usually caused by the building up of fatty streaks and plaque which accumulates on the artery wall,

due to things such as smoking, and high saturated fat diets. This can lead to a number of heart diseases such as thrombosis's which can be fatal, if the thrombosis moves to the heart stopping it from functioning, which would require artery bypass graft surgery. With the help of nanotechnology we can help keep the artery systems clear and therefore, allow them to function healthily. (Drugs, usually proteins e.g.) pectinase, can be attached to the surface of a nanoparticle which is inserted into the body and attaches to the surface of the blockage in the artery causing it to be cut down. Nanoparticles are lipid based molecules which group together to form a sphere shape called a micelle. The pectinase is attached to the surface so it can be released onto the plaque. At the University of Santa Barbara, this theory was tested on mice. They were fed a high fat diet, and the researchers inserted Nanoburr's, which are nanoparticles coated with a tiny amount of protein, they watched the effects, and saw that the protein they used stuck to the target area and released drugs for up to several days(http://www.understandingnano.com/nanoparticle-targeted-drug-delivery-arterial-plaque.html). In addition, the use of nanoparticles does not only help destroy the plaque which can accumulate in the arteries, but it can detect the plaque building up. This is because the nanoburr's lock on to the specific structure of the artery, and if this structure changes, for example, due to an inflammation, the drug can be secreted onto the area. This advancement in treatment has helped the medical world greatly.

Thanks to nanotechnology, if caught early enough it can prevent the need for artery bypass surgery, because the drug could be used to rid the artery of any fatty deposits which could cause a block or a haemorrhage. Furthermore, it could help reduce the need for stents to be implanted, and therefore, has helped to revolutionise medicine in this particular area, by reducing the need for more time consuming and difficult procedures.

Cancer

Cancer is a term used for a disease in which abnormal cells divide uncontrollably which can also invade other tissues and spread. This happens when cells become old, and are dying because they are more prone to get damaged and mutate which disrupts the process of replication by mitosis. Due to the replication process being incorrect, the cells mutate and replicate passing on the wrong characteristics causing them to abnormally grow uncontrollably forming a tumour.



http://www.cancer.gov/cancertopics/cance 1

There are more than a hundred different types of cancer. In 2007, 298,000 people were diagnosed with cancer. There are different ways in which cancer can be treated. Immunotherapy, Surgery, Chemotherapy, Radiation Therapy and Biological Therapy. Most of the treatments for Cancer have side effects that can cause lasting damage to the body. If we use nanotechnology to combat cancer it can help reduce the number of patients who suffer from the many types of cancer and the side effects of the common treatments. Currently, the two most common types of treatment for this disease are chemotherapy and radiotherapy.

Chemotherapy is used to treat two types of cancer – Leukaemia and Lymphoma. It works by killing the cancerous cells in the body. It does this either by being injected intravenously near the affected area, or the use of cream and oral drugs can be forms of chemotherapy. (http://www.macmillan.org.uk/Cancerinformation/Cancertreatment/Treatmenttypes/Chemotherapy/Beingtreated/Havingchemotherapy.aspx)

Radiotherapy is another way of treating cancer; it works by firing high energy rays at cancerous cells to damage them. This stops them from growing and dividing. Radiotherapy can be fired from an external source (gamma ray machine) or inserting a small implant that contains radioactive material, directly in to, or near to the tumour. (http://www.medicinenet.com/radiation_therapy/article.htm)

Nanotherapeutic drugs are in the process of development for the treatment of cancer. Nanotechnology has made it possible for drugs to be implanted in to the body to treat this disease. In 2005, a nanodrug was created called Abraxis for the treatment of breast cancer. Furthermore, another approved nanodrug has been produced called pegylated liposomal doxorubicin; to treat ovarian cancer. Nanoparticles coated with a small layer of gold can be attached to tumors and heated using infrared radiation. In addition, nanoshells can be altered to absorb certain infrared radiation frequencies.
(http://www.nano.gov/html/news/SpecialPapers/Cancer%20Sidebar%20for%202005%20Budget%20Supplement.htm)

This use of nanotechnology allows us to selectively destroy cancerous cells and tumors. This type of nanotechnology can be bad because the invasion of nanoparticles can trigger an immune response, leading to the destruction of the technology as it is seen as foreign. Furthermore, we don't truly understand all the affects of nanotechnology in the body; therefore nanoparticles could cause harmful reactions to the patient. Finally, the nanoparticle might not be able to be controlled sufficiently and could start releasing drugs at the wrong target. On the other hand, this type of nanotechnology could revolutionize the treatment of cancer in many ways. Nanotechnology could lead to the successful treatment and extinction of many of the most harmful diseases that the human race suffers from today. For example heart problems like myocardial infarctions and the many types of cancer that human society suffers from today. Thanks to the use of nanotechnology we can reduce the amount of harmful cancer treatments that hospitals use today like radiotherapy. Also, advancements in immunosuppression will continue to grow which in the future will allow us to combat the immune response that might be caused by the invasion of nanoparticles into the body of a patient.

We believe that there are other uses for nanotechnology in many fields of medical research. We hope that the advancements in nanotechnology might lead to the cure of the common cold and other virus's such as the influenza virus. We think this because; an implant of nanoparticles might be able to find the pathogen, which is the source of the common cold. The nanoparticle could be carrying a protein, or have a gold coating which would allow the application of infrared radiation to be heated and destroy the foreign source, or the protein will destroy it. However, this would require much research in to the phenotype and the cause of the virus, so it we could determine which protein would be capable of destroying the pathogens. Furthermore, it would require much investigation, as viruses are continually mutating and so it could be potentially very expensive and difficult to find a single method which could eliminate the source and cure the problem.

Another future development of nanotechnology that we hope could be achieved is the use of nanomaterials to create artificial organs. This would solve many problems which humans suffer today. The creation of artificial organs using nanomaterials could be an easy cure for a failure of a kidney, rather than using a dialysis machine which provides a poor quality of life and are expensive to maintain. This means that with the correct funding, artificial organs would be more easily mass produced than dialysis machines. Another illness which could be cured by the use of nanotechnology is diabetes. If it would be possible to manufacture an artificial pancreas, which if supplied with insulin would function like a normal pancreas. We have mentioned earlier in this paper about materials that are being developed using nanotechnology that can react to level of glucose in the blood. If an artificial pancreas could be created out of a material like this, diabetes could eventually be cured. The only problems with such developments would be the expenses caused to the countries that develop these advancements. Overall though we believe the difference made to the lives of all patients, and the amount of illnesses advancements in nanotechnology could cure, would be worth the money invested into the development of these technologies.

Conclusion

Overall we believe that Nanotechnology is of vital importance to future developments in medicine. In our paper we have discussed how Nanotechnology is currently used in the treatment of certain diseases. The uses of nanotechnology to treat diabetes helps to make the needles used in self-monitoring of blood glucose (SMBG) have antibacterial properties. This means that needles will not cause the spread of disease and promote a safer treatment of diabetic patients.

We have also looked at ongoing developments in the field of Nanotechnology used in medicine. The development of nanoparticles coated with a thin layer of gold is currently in development. This will allow doctors to inject a patient with these nanoparticles, once the nanoparticles have reached the area of the body where the illness resides, the nanoparticles can be heated using infrared radiation. The heat will irreparably damage the foreign body therefore curing the patient. These nanoparticles are referred to as gold rods or Nanorods and can be used to treat problems with the heart and kill cancerous cells. Another ongoing development in the field of nanomedicine is the use of nanomaterials that react to the level of glucose in the blood by releasing insulin. This would end the need for needles to inject insulin especially if the material being made from nanomaterial could be put under the

surface of the skin. These are both currently ideas being researched by scientists for use as medical treatments.

Though the use of nanotechnology is important in medicine there are also many ethical issues to be considered in this paper. The use of nanomaterials like the Bucky Balls in delivering drugs or stem cells to certain parts of the body causes ethical debates because scientist are not allowed to use cells from a human when experimenting on the effects of this type of treatment. This can cause ethical debates because only animal cells can be used. This is seen by some as wrong on many levels. First of all this use of animals could be seen as animal cruelty. Rather the major problem with using animal cells is the fundamental fact that they are not human cells. There could be unseen side effects to using animal cells in treating problems within a human body. It would require a lot of research to prove the use of animal cells is safe to human patients and would therefore be expensive.

If such advancements in the use of nanotechnology are possible, then surely the future developments that we hope can happen are not only possible but also, within reason, capable of being developed in the not too distant future. The idea of using nanomaterials to create artificial organs is already being researched e.g. in the making of an artificial pancreas to cure diabetes. Why then can we not maybe create an artificial kidney out of nanomaterials in the future?

Overall then, the development of nanotechnology to be used in medicine could be seen as one of the most important developments of the modern day. Nanotechnology is already put to good use in treating many patients suffering from a range of different illnesses. Therefore the ongoing research in the field of nanomedicine could be said to be of the utmost importance as it could be considered the cure to many of our problems like cancer, heart disease, diabetes and many other illnesses suffered daily by people all around the world.

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