The Future Prospects For Nanotechnology

Within The Medical Field

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PASS

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Abstract

This short paper is about the prospect of Nanotechnology in the medical field, its current state, and the possibilities it holds. I will also briefly be discussing the ethics of nanotechnology and impacts it could have on a worldwide scale, along with mentioning a small history of the subject.

Introduction

Nanotechnology is becoming increasingly more researched and studied in the scientific community for its growing potential to create huge advancements in the scientific field. Richard Feynman first triggered a serious interest in the concept with his "there's plenty of room at the bottom speech," in 1959, in which he argued it would possible to manipulate matter at an atomic level with the right equipment. [(1)] The concept interested many scientists as it worked on the idea that when approaching the atomic level, forces considered important at the human level such as gravity become less significant, whereas forces such as Van der Waals become critical to take into consideration.

The term nanotechnology, coined in 1974, comes from the idea of technology at a Nano scale, Nano meaning 10^{-9}, so one billionth of a metre; roughly the size of 3 atoms. The name was coined in a paper, which was representative of the interest in the very new subject at the time. More papers were released including the revolutionary '*Engines of Creation: The Coming Era of Nanotechnology'* published in 1986 and written by Dr. K. Eric Drexler, of which a free version may be found here: http://e-drexler.com/d/06/00/EOC/EOC_Table_of_Contents.html.

Dr. K. Eric Drexler's book promoted a worldwide interest in the subject, which was also helped by the discovery of Fullerenes in 1985- the most famous being Buckminster fullerene sometimes known as C_{60} or Buckyballs- and the development of Carbon Nanotubes in subsequent years. Both discoveries were the biggest advancements to date in the field of nanotechnology, and the former won the 1996 Nobel Prize in chemistry. [(2)]

In the subsequent years since Richard Feynman's famous speech nanotechnology is being increasingly researched as a way to advance medicine, and new developments can already be seen to be made under the name of Nanomedicine, with the journal Natural Materials declaring in 2006 that an 130 nanotech-based drugs and delivery systems were being developed worldwide. [(3)]

Nanotechnology could be extremely useful in the medical field because of the minute size of cells. An average cell is 10 µm, or 10,000 nanometres. Whereas normally equipment would be measured in centimetres, Molecular machines made using nanotechnology would be in the size of several hundred nanometres or micrometers, thus being able to work on much smaller objects such as single cells, instead of entire lumps of tissue. These molecular machines may be composed of many hundreds of proteins or similar substances, which will then be able to chemically alter cells.

As an industry Nanomedicine is growing rapidly, with reported sales accumulating to 6.8 billion dollars in 2004, and a minimum of 3.8 billion dollars is being interjected into the Nanomedicine Research and Development field each year. [(4)] It has long since surpassed the works of science fiction, and is becoming more and more prominent to the public with such ideas as new ways to cure cancer, administer drugs or repair cells.

Discussion

One of the major ways in which Nanotechnology may hold the key to serious advancements in medicine is through the administration of drugs. When a person takes a dosage of drugs, a high proportion of this dose is given to the wrong parts of the body, instead of the target, which results in the loss of billions of pounds worth of drugs each year worldwide. Nanotechnology has the potential to ensure that this

administration of drugs is far more accurate. The accuracy of a drug to reach its desired target is called drug bioavailability.

Some nanoparticles are able to administer drugs, and many are under development to target specific diseased cells, I believe this could be especially useful in helping to cure cancer. When a person develops a tumour from a cancer, this becomes deadly as it crushes vital organisms in the body because of its rapid growth; however this rapid growth need a much larger blood supply than most tissue in the body. If nanoparticles that killed cells were administered to the blood stream, many of these would be taken straight to the tumour because of the large intake of blood, causing considerably more damage to the tumour than to the rest of the body's cells, this could effectively kill the tumour while causing damage on a far smaller scale to other areas of the body. Although other areas of the body could still be affected, this would not be on such a large scale as current cures such as chemotherapy, and would generally be seen as a better outcome than death.

Not only this but if the nanoparticles could be designed to administer the drugs to only diseased cells, then the resultant damage would be minimal. This would be a lot easier with a cell which has been riddled with a disease which has been causing by an invading microorganism, as the nanoparticles could be activated by the invading microorganism by the antigens on the microbe, or be activated chemically by the microorganisms and resultant change in the cell. This would leave the healthy cells in the body completely unharmed and also mean that basically none of the administered drug is wasted. As of yet this is theoretical as nanoparticles which could be activated by antigens on invading microbes, or chemicals released by them are yet to be created.

This method could not be used completely on a cancerous cell, as the cancerous cell is genetically the same as a healthy cell, however is not able to regulate its process of mitosis, therefore this method would need to be altered. I propose that these nanoparticles should yet again be used, however instead of being activated by antigens or chemicals, be activated by radiation. The nanoparticles would be administered into the bloody stream, and because of the nature of a tumour needing a lot of blood a large proportion would be sent to the cancerous target. Radiation could then be used upon the nanoparticles to make them release the cell destroying chemical. Alternatively the nanoparticles themselves could emit radiation which could then destroy the cells. The radiation in the second method would need to have a relatively short half life to ensure it did not have a prolonged stay in the body. Not only would this but special consideration would be needed to ensure that this would not cause damage to other areas with a high blood supply, such as the heart or brain. For this reason I propose that the method using the radiation source from outside the body be used, as there is less chance of radiation damage to healthy cells as the tumour can be especially targeted.

The advantages of curing cancer patients via this method instead of others are huge. Firstly cancer patients will not have to undergo extensive sessions of chemotherapy, which can cause huge discomfort to the patient, severely lower the quality of life, which in the form of palliative care is something vital to take instead consideration. Also patients will not need to be given such high doses of drugs such as steroids which can again cause discomfort and emotional problems too, such as mood swings.

Nanoparticles could also be used to help locate cancers and could be much more useful in the early stages than imaging such as X rays, which requires quite a thick tumour for it to show up on imaging. These nanoparticles could work by releasing radiation (in the form of gamma so that it can escape the body) which would then create an image of where in the body the highest amount of radiation was being released from. This would be areas of highest blood supply, such as tumours. However this would not be useful for spotting brain or heart tumours where there is a constant high blood supply. Also this radiation would, as stated earlier, need a short half life to stop radiation poisoning.

Some nanotechnology is already under way to help locate diseases, thus showing the potential of such an idea. Iron oxide containing nanoparticles have already been proven to help enhance the imagine of an MRI scan on cancer patients. [5]

Nanotechnology could also be used for cell repair. Given that nanotechnology works on such a small level, specific cells can be targeted in ways that cannot be done so in nearly any other method of approach known to date. Molecular machines would be used to help repair individual cells.

It is important to not misunderstand the idea of a molecular machine. Because they are such tiny molecules, it is critical to understand that they would not be machines in the science fiction or the human sized world sense, with mechanical arms etc to help repair the cells by physically moving them, rather they would be small chemical molecules, maybe proteins that are roughly 600 proteins long for example. This is important because sometimes within a cell, a chain of proteins can cause a huge difference to its functioning properties.

Because this method would be used to target specific cells, this could be achieved by the particles recognising a cell by the antigens on a cell membrane. As a result of different types of cells carrying different antigens (for example the antigens on a muscle cell and a nerve cell would carry) the molecular machines would be able to target specific cells. The molecular machines would then alter the cell by a chemical reaction and cause the cell to function properly.

This would be revolutionary to cells which the body is unable to repair normally, for example brain cells and nerve cells and could hold the key to helping a stroke patient regain control of their actions again, or allowing a disabled patient to walk. The cells mentioned before are also too small and fragile to work or manually in surgery with huge success, and in some terms such as brain cells can be dangerous to work on in open or even keyhole surgery; therefore this method of healing would be a huge advancement to medicine, with a much lower to minimal risk of infection.

The molecular machines if unable to attach to the antigen of a cell, could be administered to the cell directly as scientists are able to inject needles into a cell without killing the cell.

Theoretically because of the minute size of nanotechnology, nanoparticles could be designed so that they could be used to alter even a person's genes. Although this would take huge amounts of effort to be of effect at an adult level, at embryonic level this could be a huge development, because if a Zygote was genetically altered, then when it develops into an embryo all the cells within it would have the same genetically altered material that the zygote had. This could be extremely useful in helping to cure diseases that are genetically caused, such as Ulcerative Colitis and many more.

This method of altering genes using nanotechnology would however require the parent(s) to choose to have an IVF baby instead, as this would be the only way to possibly administer the nanoparticles during the zygote stage. Also this would not be possibly for many years yet, as nanoparticles are not yet able to successful and accurate alter the human genome and the human genome would need to be understood in much greater detail. This could lead to ethical issues such as parents changing the looks of their child, such as eye or hair colour, by altering their genes. However ethics shall be covered later.

By altering the human genome this could again be used in helping so far incurable conditions such as paralysis. This could be done by altering the genes of a human adult stem cell so that they can specialise into any cell, which is not possible with the current genetic set up of an adult stem cell. As an example nerve cells could be created, and then administered to the patient which would help to cure paralysis. Also because the cells would be grown from the patients stem cells, taken from the bone marrow there should be no rejection from the body providing the antigens were not altered whilst the genes were being altered, therefore the

would be no need to administer the patient with a constant supply of autoimmune drugs such as Azathioprine, which could cause discomfort.

Much like how nanoparticles could be used to help destroy cancerous cells, they could also be used to destroy invading microorganisms such as viruses. The nanoparticles could be used to alter the viruses using chemical reactions if scientists knew which nanoparticles could be used to destroy which viruses. Alternatively nanoparticles could be used to attach to the receptor sites of viruses which are needed for entry to cells by chemically bonding to them, in a similar way to how our antibodies work, this could slow down the rate at which viruses work and then make them useless until they are engulfed by phagocytes. Diseases thought incurable such as AIDS could be cured, and in the case of AIDS when the virus has rendered useless the majority of the T helper cells, and so slowed or halted the production of antibodies, the nanoparticles could act as an alternative to the bodies antibodies, and slow the disease so that the body could repair itself again.

It is not simply nanoparticles which can aid in the realms of medicine in terms of nanotechnology; computer based nanotechnology such as nanochips can be used as well. Nanochips are like tiny little computers, able to do a small number of actions. Due to their small size they cannot perform huge calculations, but can perform certain functions.

It has been argued that nanochips could be used to monitor certain areas of the body, such as the brain, and help to regulate epilepsy within patients. [(6)] These very chips could also be used to help increase sensory feedback within nerves, and help patients with damage nervous systems. If nanochips with different functions could work together, then I argue that diseases such as epilepsy could be completed cured using nanochips, by the nanochips regulating the brains activity and ensuring seizures did not happen, or were extremely weakened. This could save people's lives along with help developments into other diseases caused by malfunctioning brain activity, by using nanochips to regulate things such as schizophrenia.

Extensive research into Nanotechnology could lead into a worldwide ethical debate, much as the case with stem cell research. Although with nanotechnology there is no harm done to living humans embryonic or otherwise, many people would still believe it is 'playing god'.

Research into nanotechnology could eventually lead to the curing of paralysis, an event which would generally be seen as a positive impact the world over. However religious extremists would argue that to be able to make people walk who have never been able to would be interfering with gods will and is too powerful. There could be serious objection from very orthodox religions, such as strict areas of the Catholic and Muslim faith. However is it truly right to deny someone the right to walk and be an equal opportunity in the world?

Not only this but if genes could be genetically altered at birth, this could cause an even bigger outcry from the public. Many people would be wanting to have the 'perfect baby' created, to be strong and intellectual, with the right colour eyes and hair and this cause widespread discrimination, as well as lowering variation in the human race. Where as it may be right to prevent illnesses at birth, I believe that to alter peoples appearances just for the sake of vanity, is displaying a serious disregard for morals, and would cause discrimination amongst the 'less perfect'. Ideas similar to that of an 'Aryan race' could emerge within cultures. However that said I believe severe disfigurement should be allowed to be altered during the development stages providing scientists can identify the genes responsible, as this goes outside of the normal appearance for a human being. World Governments would need to ensure that laws were put into place to stop babies being altered for anything other than health and extreme medical reasons.

Other problems could occur too, for example how nanotechnology could be spread amongst different countries. Poorer countries such as many in Asia or Africa may not be able to afford the nanotechnology that could save many of its citizen's lives. Although charities would help pay a proportion of the bill to ensure this

new promotion of health was wide spread, world governments would also have to supply aid or else be accused of ignoring the human rights of citizens from other countries.

If vast improvements are made to medicine using nanotechnology, then this could cause a world population problem. Infant mortality rates in poorer countries would drop, and citizens would be healthier promoting countries of flourish, causing birth rates to increase because of better standards of living. This would within a few decades cause serious problems for population, and scenarios would have to be set up like in china where people are limited to the number of children they can have. Governments would have to pre play such scenarios, and prepare for public outcry; immigration into certain countries would also have to be seriously monitored to stop overcrowding in small popular countries such as England.

Whilst I believe that everybody should have the right to life and medicine should it be needed, serious advancements in the field of nanotechnology would cause serious problems in the way of ethical, economic and population problems which would need to be carefully planned before hand.

Conclusion

Nanotechnology has gone far beyond the realms of science fiction and is more and more being realised as a potential way to cause serious advances in the realm of medicine amongst many others. Huge advances have been made since the formation of the basic idea 70 years ago, and now more than nanotechnology is making its way onto the science scene.

Though this paper has provided some ideas of the possibilities of nanotechnology, many of the ideas are still theoretical, and involve big jumps in science to be made, and the nanotechnology to be manipulated for greater use and on a wide scale. Although it may cause huge health benefits, it may cause problems economically because of the huge costs involved making some small molecules, and it may not be able to be used on a wide scale.

The ideas in this paper, although basic and not backed up with tested evidence, do provide a basic idea as to what the future may provide for nanotechnology based upon a strong scientific understanding, and the problems such huge leaps in medicine could cause.

It has hopefully become apparent that nanotechnology is an area worth researching and I believe its potential to fight diseases and to be used in corporation with stem cell research and curing genetic diseases are huge.

The principle of locating and curing cancer using nanoparticles is scientifically sound, and provides an alternative to current methods in use today which and costly and dangerous. The area requires a lot more research to be done, and a way to destroy cancer cells without causing significant harm to the rest of the body.

However I feel that the real potential lies in incorporating nanotechnology into cell repair, stem cell research and modifying genetics. If nanotechnology can alter the genetics of a cell, that genetically based diseases could be eradicated during early development of an embryo and as such vastly improve the quality of life for that human being. Also if it can be incorporated with stem cell research, and nanotechnology can help adult stem cells to specialise into other cells, that new organs could be made and people would be able to walk/hear/see where they could not before. These are all huge advancements to be made in science, and nanotechnology is opening doors to a whole new branch of medicine.

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