Nanotechnology and medicine: the future and the ethics?

by

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PASS

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Abstract

This paper examines the use of nanotechnology, its application to the human body and to medicine, and explores some ethical debates around this issue. Topics detailed specifically; the use of nanotechnology in tissue engineering. respirocytes in the blood stream, and the diagnosis and treatment of cancers. Following the discussion a conclusion is drawn that while there may be massive potential advantages to medicine through the various uses of nanotechnology, limitations to their development may be; the massive costs involved and ethical concerns about where the technology may lead.

Introduction

Nanotechnology by definition is the study of manipulating matter on an atomic and molecular scale (Wikipedia[1]). This results in man made molecules, typically 1-100 billionths of a metre[2,] which can be manipulated in various ways to suit differing medical applications. The extremely small size of nanoparticles allows them to penetrate cells and interact with them[3] Some techniques are currently in use today whilst others exist only in the imagination, for example some wound dressings are available now which reduce the infection rate, these contain silver nanoparticles which have antibacterial properties against some common bacteria[4]. Currently in development by MagArray Inc, are iron oxide nano-particles, coated with peptides, which bind to cancer tumours. The company claims that due iron's magnetic properties, magnetic resonance images (MRI scans) are enhanced greatly, leading to improved cancer detection and tumour treatment. Nanotechnology holds the potential for exciting medical advances, such as the use of respirocytes in the treatment of massive haemorrhage, cutting death rates for trauma victims. However, such use of nanotechnology is not without many ethical concerns.

Discussion

There are many ethical issues surrounding the future development of nanotechnology in medicine. It is currently possible to 'grow' new skin for those who have suffered horrific burns injuries. This method of 'growth' consists of building skin on a nano-scale, atom by atom. If this is possible in the year 2011, then I propose that in the near future it will not just be skin that we see being built. Using the same principles, what would stop nano-scientists 'building' a new arm for an amputee or 'growing' a new heart for a transplant patient?

Today, the current method of treating a large burn-type injury is through a skin graft. This method involves taking a patch of skin and tissue from an area of the body separate from the primary wound, in doing so creating a secondary injury site. One of the main risks with this technique is that of infection. A wound that is large enough to warrant a skin graft creates a large surface area, which increases the chances of it becoming infected. A large injury is also more challenging to cover and keep sterile, especially for the time it takes to heal and allow new skin to grow, which may take up to 3 weeks. During the operation, the patient is anaesthetised under a general anaesthetic. Although skin grafts can produce very impressive results, unsightly scarring will always be an issue. I feel that nanotechnology may hold better prospects. Firstly, if a technique derived from nano-science is used then this would mean that there would be no need to create a secondary injury, drastically reducing the risk of infection. Secondly, using the technique proposed by nanoscientists – whereby carbon nano-tubes are used to scaffold over the would while electrical impulses are used to stimulate the natural growth of new skin – recovery times are greatly reduced. This again reduces the risk of serious infection and it is also proposed that this method may leave only minimal, if any, scarring.

Many would view this as one of medicine's great revolutions, although others would accuse doctors of 'playing God'. This would be due to the fact that the process is unnatural, granting a person life who, in the terms of a transplant patient, would otherwise be certainly dead. Though when building new limbs and body parts, would restrictions be placed upon medicine to limit treatment to the disabled, or would a perfectly healthy adult be able to enhance themselves? If this was the case, then an elite race would form – those who can live safe in the knowledge that, should the time arise, that a replacement organ was but a phonecall to the lab away. Or those who would model themselves as truly perfect – with designer body parts, figures and abilities.

However, aside from the fabrication of organs and body parts through nano-engineering, nano-technology may hold other answers as to how to 'improve on nature' with respects to the human body. Currently being researched and hypothesised are synthetic erythrocytes, dubbed 'respirocytes' (see fig 1).

Fig 1[5]

These artificial red blood cells have a potential capacity for oxygen 236[6] times greater than haemoglobin, the body's own oxygen transport protein. This extremely inflated value could further the fear of the formation of an elite race, those with capabilities far exceeding those of 'standard' human beings. This is because, in theory, circulating respirocytes (in the bloodstream of an adult) means that they aquire the ability to dive for up to 4 hours before resurfacing. Furthermore, while resurfacing, the enhanced diver would not have to worry of decompression sickness. Decompression sickness (or "the bends" as it is known) is caused when nitrogen, which has been dissolved in the blood at deeper depths and pressures, bubbles in the blood. To counter this, respirocytes - configured to absorb nitrogen as opposed to oxygen – could be taken by the diver in the form of a capsule as a therapeutic dose. This would mean that the diver could survive the rapid fluctuation in pressures, associated with rising rapidly through deep water, with no adverse effects. Further to this, respirocytes could also see a marked increase in the ability of sports men and women.

Respirocytes promise to deliver more oxygen to the body's respiring tissues, quicker. This would eliminate anaerobic respiration in muscle cells, meaning that no lactic acid is produced, which in turn means that an athlete would have a heightened endurance and the ability to exercise for longer. Coupled with this, the sports person would also have a spiked maximum exertion level due to improved tissue oxygenation. Could this then mean that, in the future, we see our sporting heroes being doped and tested not for steroids and other enhancement drugs, but for artificial, nano-scale molecules coursing through their veins? Or would the first production of respirocytes really further the risk of an elite race, those that now not only have designer body parts and organs, but now have superhuman capabilities? This surely has to be a threat considered by regulating bodies before this branch of nanotechnology bursts into medicine. Although, potentially outweighing these factors, are the ways
in which these nano-scale oxygen carriers could revolutionise healthcare.

One of many areas of medicine that could benefit from the development and application of respirocytes is in the treatment of anaemia. Anaemia, by definition, is

the shortage of erythrocytes and/or haemoglobin in the bloodstream. This problem would easily be overcome with the use of respirocytes, as once in the bloodstream (via capsule or transfusion) they would be capable of delivering high levels of oxygen to cells and tissues, relieving the symptoms of anaemia and any lasting effects. This treatment, if as effective in practise as in theory, would revolutionise medicine because of the wide spectrum of anaemic patients in hospitals. Anaemia can be caused by a lack of iron in the body, meaning that it is unable to produce the protein haemoglobin for oxygen transport in red blood cells. This lack of iron would be irrelevant should respirocytes be used as they are not produced within the body, meaning that the patient should see a dramatic improvement in their symptoms of anaemia relatively quickly. The symptoms of anaemia can include: fatigue, weakness, loss of consciousness and in severe chronic cases there may even be heart palpitations. Anaemia can also be caused through excessive bleeding, during childbirth or trauma for example. This could cause a threat to life if a large proportion of red blood cells are lost, as the body will no longer have any method to transport oxygen throughout the body. Again, if respirocytes could be used in this situation, this would be beneficial as they are theoretically capable of carrying and transporting many times more oxygen per unit volume than erythrocytes. This would help to maintain the function of the body, without the symptoms of anaemia, until the bleeding has been controlled and normal red blood cell levels rise and stabilise. Deaths through trauma could be significantly reduced through the use of respirocytes. A large percentage of trauma patients, for example those who have been involved in a traffic accident, die through extreme blood loss due to their injuries. This is because their brain, organs and tissues become starved of oxygen which causes the cells to die. If the patient had had respirocytes in their bloodstream, however, which – per unit volume – can carry 236 times more oxygen than the equivalent red blood cells, then their cells and tissues would have had a greater initial supply of oxygen and an awful lot more of this artificially enhanced blood would need to be lost to reach such a low level of oxygen that the cells would die. Respirocytes given to patients by emergency personnel at the scene of a major trauma may mean that patients in this situation may well survive. Respirocytes used in this domain however may still be criticised as the use of nano-particles and non-biological molecules is seen as unnatural. Furthermore, the use of nanotechnology in medicine will face conflict from those who are true to religions. In Christianity, for example, it is believed that God created the human being in his own image, and is therefore perfect, and that whatever God gave you should be accepted. It may be interpreted that nanotechnology, and specifically respirocytes, seek to improve on this – allowing the human body to do things it is unable to do so naturally. Jehovah's Witnesses on the other hand are fundamentally opposed to receiving blood transfusions, or other blood products, and this may mean that their lives end
earlier when faced with anaemia, or massive blood loss than would be the case if they were accepting of treatments. Would this religion be similarly

opposed to respirocyte treatment?

Whether resirocyte treatment will be feasibly possible, however, remains to be seen. There are some questions that the laboratory currently cannot answer. One such question would be towards the long-term effects of nano-particles on the human body and whether it’s innate functions and processes will be affected.

Another field of medicine that I see being affected by nanotechnology is cancer. Under development at this present day are many different techniques, all of which set to improve either the way cancer is detected or the way in which it is in fact treated. AuroLase™, a technique being developed by Nanospectra Biosciences Inc. uses nano-particles which circulate the patients bloodstream, only leaving the blood vessels where the blood leaks at the tumour site. The synthetic particles accumulate around the tumour, which is when an infra red light or laser is shined onto the area. The nano-particles, designed specifically for their heat conductive properties, absorb this light energy and transform it into heat energy – incinerating the tumour yet leaving the surrounding, healthy tissue undamaged. Also being developed are iron oxide nano-particles, coated with peptides, which bind to a cancer tumour. MagArray Inc.[7] claim that because of iron's magnetic properties, magnetic resonance images (MRI scans) are drastically enhanced. This therefore improves a surgeons view of the whole tumour, its orientation within the body, and its interaction with other organs, tissue, vessels and nerves.This visually improved image allows the surgeon to make a more educated and informed decision of the course of action to take, thus improving the outcome for the patient.

If the application of nanotechnology to medicine continues as I have predicted, then this may have a more significant effect on the planet and it's population than previously expected. Through the use of tissue engineering, I can see organs being tailor made for a person with perhaps only a small tissue or DNA sample. This, therefore, would spell the end of death through organ failure. Further to this is the amount of lives saved worldwide thanks to improved cancer treatments and detection, all of which having nanotechnology at their foundations. In 2008, 7.6 million people died from cancer making it the largest killer that year – accounting for around 13% of all deaths the world over[8]. Assuming that a large percentage of these people could have been saved through the aforementioned techniques, and coupled with the ways in which nanotechnology plans to save trauma and transplant patients, then world death rates are set to fall dramatically as soon as the technology is ready to be implemented. This, however, creates many problems in itself. World population rates have been increasing for many years, from around 6 billion in1999[9] to an estimated 6.85 billion in 2010[10] .If less people die each year due to nanotechnology also, then this level of inflation is sure to balloon. This would impact our planet's already dwindling natural resources, such as fossil fuels and even food. If the world population does rocket without restrictions and regulations on birth control and

healthcare, the world is going to find itself suffering from starvation, a disease that nanotechnology has no answers to.

Until the present day, research into the medical application of nanotechnology has received billions of dollars in investment, through governmental and private support.I feel this shows the caliber of the potential in this area of medicine and therefore what we may expect in the future. However in such economically challenging times governments are struggling to justify heavy investment in medical research. The UK Centre for Medical Research and Innovation (UKCMRI) has had £233 million cut from its budget, forcing its new biomedical research facility to be phased over the next six years. This may mean that my vision for the future for nanotechnology application within medicine will be delayed significantly if not stalled completely.

Conclusion

In conclusion, nanotechnology has the potential to do many great things in medicine. From potentially eliminating trauma deaths due to blood loss, through to wiping out the fear of cancer which currently plagues medicine. However, it is not without its limitations. The development of such technologies carries with it a great financial cost, one which - in the eyes of worldwide governments – may not be justifiabe in the current economic climate. There is also the question as to whether we, and medicine, should be exploring the unnatural use of man-made products of nanotechnology in the human body, not knowing the potential long term side effects of such actions.
It would be ideal to think that these technological revolutions would be used solely to save lives, however, the true fact is that nanotechnology has the potential to be missused. For example, in the wrong hands, certain aspects of nanotechnology, eg. respirocytes, could be used to develop an elite race. The subject of the development of nanotechnology in medicine is one which will need to be heavily regulated, controlled and discussed by large multi-national organisations.

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9

7