FUTURE APPLICATIONS OF NANOTECHNOLOGY IN THE FIELD OF MEDICINE

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Abstract
The research that we have undergone whilst producing this paper is aimed at discussing the possible uses of Nanotechnology for the benefit of the wider community, through the field of medicine. To date there have not been many major breakthroughs in this area, however, based on the research that we have undergone, we have looked at some of the potential possibilities for futures uses and the ethical issues surrounding the development and the use of these medical advancements.

Introduction

Carbon has caused interest in many areas for many years, due to its unique properties. Carbon has the ability to form four covalent bonds with nearly any other element. This enables carbon structures to form and to be influenced in ways that are desired by the user.

Recently a form of carbon structure has been discovered that is now known as Buckminsterfullerene or by its shortened name “Buckyballs”. These are giant covalent structures that are made of only carbon atoms. Typically 60 carbon atoms join together to form a roughly spherical shape, the same as the panels on a football. This is shown in Figure 1.

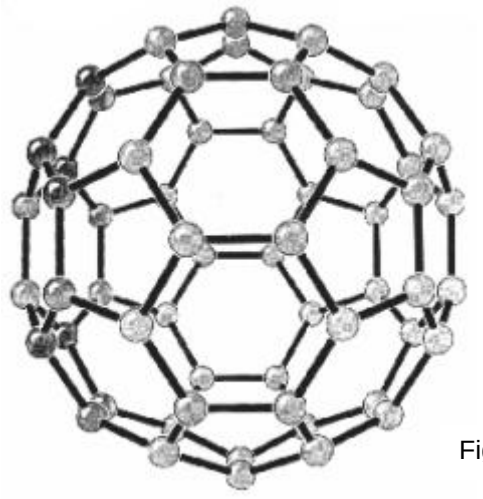

Figure 1

These structures have led the way to the development of a new field called “Nanotechnology”. Nanotechnology in its most basic form is the branch of engineering that deals with the manipulation of individual molecules, typically the objects are 100nm or smaller. Nano refers to the prefix determining the minute size of particular things. Technically, a nanometre is 0.000000001m, or 10^{-9}m. To put this into a sense of perspective the human hair is 200,000nm in diameter.

Theorising about Nanotechnology is not new. In 1986; Eric Drexler wrote a book called “Engines of Creation – The Coming Era of Nanotechnology”. This looked at the possible application of the new and experimental field of Nanotechnology. He understood the potential positive and negative impacts of using Nanotechnology.

The largest breakthrough in the field of Nanotechnology to this date is “laser tweezers” these enable the user to manipulate individual atoms, allowing them to move them round at their will. While this could be very useful, however, a practical application for these advancements has not yet found home in the field of medicine. However it is likely to be there within the foreseeable future.

One of the most obvious ways that Nanotechnology could be used in medicine is through Buckminsterfullerenes, nanotubes or “Nano-bots”. The Buckminsterfullerenes could potentially be used as medical carriers. Nanotubes could be developed as hypodermic syringes or biological scaffolding. “Nano-bots” could be used to infiltrate individual cells and repair/restore them.

Discussion

Possible future advancements that could be made due to the help of Nanotechnology could potentially include; drug delivery systems, detection and treatment of cancers, cell and bone repair and regeneration.

The idea of drug delivery systems was one of the original proposals for the application of Nanotechnology. The basic principle is by using Nanotechnology as a carrier for the drugs needed, be they antibiotics, antiseptics or anaesthetics. To do this scientists are particularly interested in “Buckyballs”. The proposed method that has been stated is to utilise the “empty” space within the Buckyballs’ structure to harbour medical chemicals that can then be released once the Buckyball has reached its required destination in the body.

Our idea on drug deliver systems is to hold the chemical within the “Buckyball” by using the physics principle of polar charges. If we could find a way to charge the carbon atoms within the “Buckyballs” as well as charging the required chemical with the same polarity then they would repel each other and hold the chemicals in stasis within the “Buckyball”.

To allow the Buckyball to release this chemical we could break the double bonds within the Buckyball which would leave an electron free to use. We could then attach signalling functional groups which would act as artificial antigens. This would fool the cells into thinking the Buckyball was a protein molecule, similar to the way the influenza virus infiltrates host cells. As the cell would try to absorb the Buckyball the chemicals being held within would be released, this would ensure that the specific cells got the treatment required.

The issues surrounding this application of Nanotechnologies are quite large. Many people would feel that these advancements could be used as a form of biological weapon. If a bomb was dropped containing Buckyballs that were full of a toxic

substance, e.g. anthrax, and were inhaled by the community then many people would fall critically ill.

The detection and treatments of cancer could also make progress due to the input of Nanotechnology. Cancerous cells are different to normal cells for one reason, they have mutated DNA; which causes uncontrollable reproduction of mutated cells creating tumours. Nanotechnology could be used to help diagnose cancer in its earliest stages by systematically reading cell DNA in areas that are prone to cancerous reproduction e.g. lungs, prostate, cervix and breasts.

For this to work we would need to develop a type of nanotube that the DNA strands could fit into. Also we would need to develop a Nano sized “computer” that would react to defects within cells. If these two segments could be joined together then we would have an ideal process for seeing if a cell has mutated, as they could show us a positive or negative result for cancers in the region being tested. The “testing” devices would need to be Nano to fit through cell membranes and into the nucleolus of cells so that access is available to the DNA coding.

A major potential problem that would arise with this is the accuracy of the device, and the efficiency of cell scanning. There is also the ethical issue of whether patients would wish for their DNA to be ‘scanned’ in this way.

Injuries are some of the most common problems that doctors face worldwide. Currently, the process of regeneration of bone and muscle tissue is a slow one and not a great deal can be done to aid this. The advantages that Nanotechnology could bring to this area are substantial. Nanotubes are one hundred times stronger than steel, whilst being one sixth of the weight for an equivalent sized sample. This makes them ideal to act as artificial structures or “scaffolds” for the bone and muscle to build around. A framework made up of carbon nanotubes could be grafted into the injury site, to allow the cells to fuse faster and in the correct positon.

Another possible advantage of using this type of scaffolding in restoration of bone cells would be that the patient would not need to have an external cast in place as the nanotubes could hold the bone in place internally. This would make the patient be able to use their arm even after a break has occurred. A sling may be required to limit the movement, however not to the extent as currently used. Due to the size of the nanotube being used to hold the bones in place they may not need to be removed once the healing process has finished. This would reduce the risk that repeat fractures do not occur at these weaker areas.

The ethical issues surrounding this area of Nanotechnology would be that people find comfort in the cast. It’s a visual, physical protection to anything happening again and this brings peace of mind to the patient thus making them feel better within

themselves. By not having a protective cast on the break or fracture the person may feel vulnerable and worry that the break or fracture is not being protected which may initially limit the activity of the person throughout the recovery process. Also taking away the idea of a cast would be reversing an old tradition, casts have been round nearly as long as the humans have inhabited the Earth; for example we have reason to believe that pre-historic man used clay to form a cast if a bone was broken, and anyone who breaks a bone at the moment receives a cast. This may make people reluctant to the move away from casts.

As technology improves and advances, the idea of scaffolding to improve regeneration could develop into tiny machines, or nano-bots, rebuilding bone and muscle tissue themselves. We have the basics of machines already built, gears and shafts made from nanotubes have been produced in laboratories. These would enable scientists to reproduce large scale industrial machinery on a microscopic scale. Machines could then be transferred to the site in the body where they are needed by an injection.

One of the smallest gears that have been produced is 1.2nm across,which is just a few atoms wide. Figure 2 shows some gears next to a dust mite. The smallest gears mentioned above are 10000 times smaller than those depicted below.

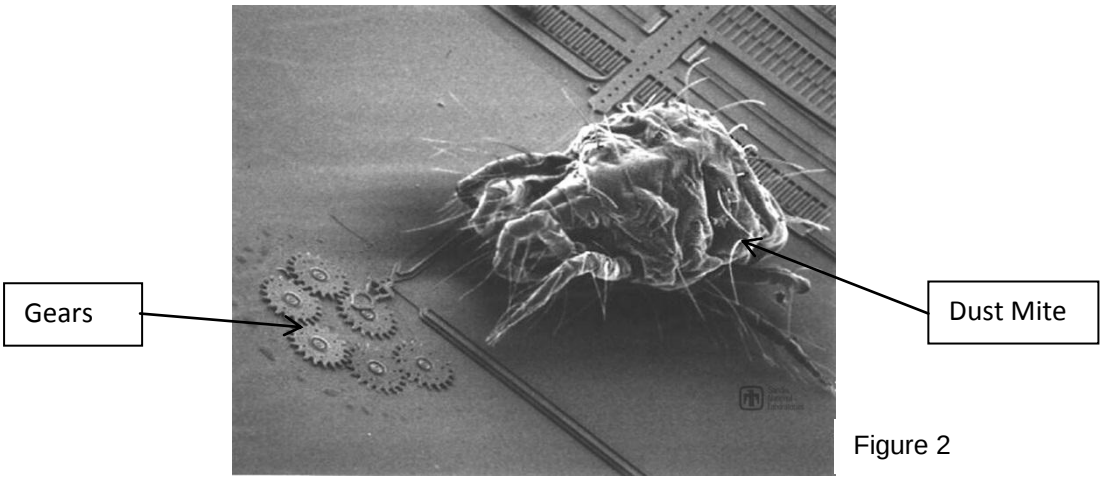

Figure 2

This area of Nanotechnology holds some of the largest ethical issues. For example would patients feel comfortable with the presence of microscopic “machines” roaming their body? Also people may fear the opportunity for the misuse of nano-bots would be high, as this is depicted in many films and video games which would spread misinformation for them. This could put a projected image into a person’s head that could lead people to be reluctant to nano-bots.

Conclusion

In the future Nanotechnology holds many possible answers and advancements to medicine. It is obvious to see the plus sides however as with everything in life, there are negatives and they need to be weighed up against the positives to see if the Nanotechnologies really are the way forward during the treatment of a patient.

We feel that once appropriate precautions have been made to the safety of the patient during administration of the Nanotechnologies, then Nanotechnologies are the way forward for medicine as they hold thousands of different ways they could be applied. Examples of this are administration of the drugs, such as antibiotics or supporting bones to help speed up regeneration rate after a fracture.

We also feel that yes Nanotechnologies could end up in the wrong hands and that they could potentially be used in biological warfare. However we already possess the technologies to use biological weapons and we don't, so why would they wait for Nanotechnologies before using them. All Governments have different agendas, some would place the advancements of Nanotechnology quite high so they may release a lot of funding where as others may see Nanotechnology as a waste of resources. If Governments release funding individuals would be able to research nanotechnologies. The research that was to take place would have to be kept secure so that it is only use for the good of the wider community.

Due to the benefits Nanotechnology holds for the wider community, in medicine as well as many other fields, such as construction and the energy industries. We believe that funding should be granted to projects aiming to research and develop ideas that use Nanotechnologies as we feel they may hold some of the ground breaking ideas within recent human history. They need time to research as it takes time to perfect things that have recently been discovered as it isn't a short process. If at the end of any research only a few ideas mentioned in this paper are carried forward we are well on the way to making Nanotechnology into reality.

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BUCKMINSTER FULLERENE http://www.chm.bris.ac.uk/webprojects2002/knowles/ (Used for figure 1)

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