THE USE OF NANOTECHNOLOGY WITHIN DRUG MANUFACTURE AND APPLICATION IN PHARMACUETICAL INDUSTRY

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This research paper explores the uses of nanotechnology in drug manufacture and how nanotechnology can be harnessed in innovative and more efficient ways. We will use current existing technology to base an educated theory of what nanotechnology could be used for in the future. We have researched new technologies to base our ideas upon such as NanoCrystal Technology which will allow us to formulate new uses for these technologies for medical application. considering the advantages and disadvantages of them and whether they are In our conclusion, we will surmise our ideas and decide whether they are appropriate ethical for use.

Introduction

Nanotechnology is new, innovative and constantly evolving. It is used in new treatments such as 'nanoemulsion'; created by James R. Baker Jr. (director of the Nanotechnology Institute for Medicine and Biological Sciences in Michigan), which is made up of particles of alcohol, detergents etc which have been reduced to 'less than 400nm in diameter'. These massive breakthroughs in nanotechnology allow us to target pathogens to such a specific degree that we can target individual bacterium cells or viruses. This means that using nanotechnology, treatments can be much more specialised to the patient as depending on the patient's needs, the nanotechnology; in this case the nanoemulsion which treats up to 2nd degree burns by reducing inflammation, can be used to prevent further discomfort for the patient by stemming the severity of the burn and preventing aesthetic damages.

Nanotechnology has scope to become one of the most valuable tools that a doctor or a surgeon can wield as due to the intricacy and accuracy of the nanotechnology, surgery and drugs can be used in ways that can detect specific antigens on a pathogen or on a cancerous cell. Nano - (meaning 'midget' in Greek) - technology, allows surgeon and doctors to change and identify matter at an atomic scale, allowing better patient care as diseases such as cancers, heart disease and brain diseases such as dementia, can be identified at an extremely early stage. Doctors can then form a diagnosis quickly and provide treatment that will be much more effective as the efficiency in which the disease was identified, allows for early care and drug/surgical treatment.

The ideas that this research paper will explore are those of how nanotechnologies face the battle against the human immune system as they reduce toxicity within drugs through stabilising molecules. Also, how molecules that were once insoluble within water so could not be ingested orally into the body, can now be ingested through pioneering NanoCrystal Technology that reduces the drug's size to mere nanometres so that 'the drug's exposed surface area is increased'. This means that older drugs that were manufactured but then scrapped due to insolubility can now be modified to contain NanoCrystal Technology so that they can now be used effectively.

Nanotechnology is very experimental and new and exciting ideas are always created by researchers. It has the potential to be one of the 21st Century's most essential discoveries that pioneers new drug treatments for disease and making breakthroughs in discovering diseases, existing and new.

Although, nanotechnology is controversial as some people believe that as it is so small, we have lost control of it, and that it could do more harm than good. Others believe that they do not wish to have small robotic type materials entering their body as it is too ‘science fiction’, and that it is unreliable. Also, the body could emit an auto immune response upon itself when a nanotechnology molecule enters the body as there is no identifiable feature upon it that will prevent an auto immune response.

Discussion

One possible advance in the field of nanotechnology in pharmaceutical applications is the development of treatments for burns, including topical lotions and anti-inflammatory products. A significant problem within this treatment is the simple fact that the skin itself is formed with the point of being waterproof. This means that it can often reject water-based substances to protect the flesh cells; too much water being absorbed could result in swelling and possible bursting from the pressure.

It is therefore a problem when second degree burn victims (who have damage to the cells beneath the immediate surface) require the hydration and antibacterial properties that can only successfully be applied through the skin. This means that it is easy for infections to cause potentially fatal harm to patients; these patients are often subjected to many invasive treatments and examinations to ensure they are not at risk, causing discomfort and risk for the health and wellbeing of the patient.

One of the possible methods of reducing this risk is the application of Nano science to the lotions. They usually consist of an emulsion of oil and water (necessary for absorption) as well as chemicals that will kill bacteria and soothe the damaged area. By reducing the size of the droplets to a minimal diameter (around 400 nanometres), the rate of absorption into the lower dermis layers of the skin significantly increases. This mean that areas that would previously be at risk of infection or dehydration due to the burn, would now be safer. This again would reduce the invasive procedures necessary for the doctor to be confident with the wellbeing of the patient.

Whilst this is one example of how decreasing droplet size can aid some more extreme cases, the theory behind it may be able to be applied to treatments for everyday use. Anti-inflammatories are often used by doctors for the benefit of a patient who complains of swelling due to an immune response (allergies can often affect people due to an overreaction of the body to certain substances). They can range from minor irritations or discomforts, to life-threatening symptoms, such as the closing of airways or blood-vessel constrictions.

It would therefore be beneficial to apply the science to anti-inflammatories. Damage to muscles or joints could be treated quickly and at a lower cost to the current method; less of the product would be necessary to penetrate the skin and aid the solution to the pain and lack of use of the joint or area. This will be useful as a treatment for the large amount of people who suffer from osteoarthritis and rheumatoid arthritis in later life. The effect of the ointments could be more effective,

whilst not having to increase the dosage of the drug. This means a safer way of combating the pain and discomfort, without risking side effects on patients who are likely to be taking many drugs at any one time.

Furthermore, the method can be applied to other, more severe situations. Cystic fibrosis can be a life changing and dangerous disease, which affects people from birth. The main problem is the blocking of the bronchioles, due to thick mucus that restricts airflow and lowers the surface area of the gas exchange surface in the lungs; this leaves people feeling out of breath and struggling even after a small amount of exercise or particular weather conditions. If the minute droplets could be included in the inhalers that many patients require, the effects of the treatment could again improve. The drugs should be more relieving, as they widen and loosen the airways, allowing the patient to be more comfortable, and stop them from hyperventilating and causing more damage. This application would be relevant for sufferers of asthma, a far more common ailment. Though not as serious, this is more widespread and improved treatment would be widely appreciated; due to the large cost of drugs necessary for all the people afflicted.

Another widespread and lethal disease is cancer, which collectively causes a huge amount of the deaths per year in many countries; it is surpassed by few illnesses, the most notable being heart disease. Work is already being done on nanotechnology that would surpass our bodies' own method of recognising foreign microorganisms in the blood stream- the antibody and antigen complex. But this method fails when it meets a disease such as cancer. This is an ailment in which the body's cells mutate and can no longer control their reproduction limits- resulting in dangerous growths that can block the person's vital organs or mechanisms. Because they are our own cells, they cannot be recognised and therefore are safe from our immune system. At this point, nanotechnology may be able to be applied in the future. We may be able to produce tiny components that will respond to all of the antigens on a cell, not just the ones relating to identification; different concentrations of these will signal whether or not the cell still has its reproduction limit intact- it will not be a dangerous cancer cell. If not, and the cell is malignant, the component can be fitted with local poison, to effectively initiate chemotherapy in a highly localised area, significantly reducing the chances of unnecessary damage to the body.

As previously mentioned, one of the few problems that supersedes cancer in its fatality rate is cardiac problems. A lot of these are caused by the poor diets, and lack of sufficient exercise done by many people; this can cause a build up of fat in our blood stream, as well as formation of hard plaque (atheroma) inside the blood vessels as a reaction to fat in the vessels. This increases blood pressure, making the heart have to work harder to pump the blood; it can also cause thrombi (ruptures in the vessel wall, causing clots and blockages), embolisms (thrombi breaking off and becoming lodged elsewhere in the circulatory system), aneurysms ('ballooning' of vessels due to stress) or haemorrhages (bursting of aneurysms causing internal bleeding). All of these can be fatal- or life changing- on their own, and can often

accompany each other. It seems therefore that the idea of a product that could pass into the blood stream without interfering with the cells or systems could be applied; if one could circulate through the blood until it detected deposits of fat or plaque in the vessels, it could be triggered to release emulsifiers or reactants that would dissolve the problem substances. Having done this, it could be flushed out of the system, along with the loosened fat and plaque, and would hence reduce the chance of life-threatening heart diseases and may save a large number of lives. It would furthermore be applied in opposing strokes (bleeding on the brain, causing physical and emotional problems, including risk of death), as blood pressure would be lowered and the probability would be also.

Nanotechnology itself is neither ethical nor unethical. The technology itself is value-neutral — it is what we do or don't do with it that can be evaluated. The technology itself does not come from endangered environments, nor from harming animals, or creating mass waste such as nuclear power does. In this instance, nanotechnology could be viewed as neutral. However its development leads to debates that mark any scientific advance. For example the technology is being tested on animals. Since modern science development was established; animals, such as mice, were used for testing. This is necessary in the development of nanotechnology, for the reason that there is massive uncertainty in nanotechnology. The side effects are that it could cause an organism more evolved than cells grown within a Petri dish to experience unknown effects from the form of nanotechnology being used and this brings into consideration the long running debate of whether it is ethical to harm animals in the development of science to protect human beings.

Ethical issues form almost half of all scientific research. If a new treatment is being researched and it could form deadly side effects, journalists immediately report upon this and this can cause a massive backlash against the treatment, such as the 1990's MMR (Mumps, Measles and Rubella) vaccination scare. As people are highly influenced by the media, when using new technologies such as nanoemulsion to reduce inflammation in arteries, causing vasodilation, this could also bring unforeseen risks. For example, if too much of the nanoemulsion is applied to an inflamed area, could this cause a decrease in blood pressure in that area? This would prevent cells getting the oxygen they require and could make patient feel exasperated, especially if the area they are treating is large, such as the lower back.

Many ethical points are argued by many campaigners but, a rarely considered perspective is the ethical implication of *not* using nanotechnology to address the tremendous challenges of disease, and the implications they bring to people who suffer through them. Is it ethical to allow someone to suffer if the potential to cure them is available? This argument suggests that it would be a lapse in moral responsibility to not continue our investigations into the effect of nanotech. So if it established that moral responsibility suggests continuing to research, what harm can the developed nanotechnology do to human beings? Well this is currently unknown. Nanotechnology has not been classed as a harmful technology. Science fiction films suggest technology such as this can become an element that thinks for itself and could become autonomous. The potential harm is only as much as we create for it. Developments always bring a risk. Cars kill thousands each year, but is it the car that causes the damage, or the person driving? Being able to engineer materials means

we can blunt any potential hazard as we design them. The main ethical issue with nanotechnology is the unknown. There is no long term development; it is new, and therefore exciting for the future. But we must not run away with the thoughts of the potential developments. Time and care must be taken at each stage of the journey of nanotechnology in development of medical uses to guarantee safety to people in stage of design, development, testing, and general usage. However if this can potentially save millions of lives it is imperative that the potential is fully investigated.

Conclusion

Nanotechnology is one of the most exciting potential developments of the twenty first century. The potential the minute particles have to bring hope to millions is quickly evolving as it becomes clearer how different aspects of medicine can adopt nanotechnology to help fight illness, infection and disease. But is too much hope being placed in this technology, in particles so small that If we consider the distance between the earth and the sun to be one millimetre, then the length of one nanometer is only the distance from New York to Boston; Comparatively 10^{-9} metres. One of the amazing uses Nano technology has the potential to do is to deliver drugs to specific areas in cancer patients. If this were to work it would mean patients undergoing chemotherapy would not face the renowned side effects that accompany the uses of the drugs. This will allow the drugs to be more effectively transported to the developing cancerous cells, and has the potential to stop for example the loss of hair associated with these treatments. However is it right to suggest that these developments will be able to work effectively within humans? Truthfully it is not.

Developments are at an extremely early stage. Testing of the Nano technology has been limited. For example on cancerous cells it has been tested on lab grown cells, and on mice, however no human has yet been completed. This leads on to another question: ‘what are the potential harmful effects of Nano technology?’; Allowing essentially, untraceable particles to enter our bodies with unknown consequences. So should testing ever be allowed on humans? In cancer cases for example, the ‘Nano bots’ would carry harmful drugs to enable it to fight the disease, but what if the drugs don’t travel to that area? The human body is much more complex than a lab grown section of cells, and more advanced too than a mouse’s circulatory system. Imagine if these toxic materials were instead to be transported to the brain. This could have devastating effects on the patients being treated, and could lead to death.

The risks of nanotechnology are therefore not known enough to safely evaluate. It could cause serious harm, however if the nanotech did successfully reach a specific area of cells before depositing of its toxins, it could stop painful suffering to the patient. So the safety aspects need continuing development and investigation. The potential of nanotechnology for medical uses can also stretch further than developing ways to cure disease; it can also be used as a preventative method of stopping illnesses occurring. More than 4,500 children die each day, and 80% of the developing world's illnesses are a direct consequence of not having access to clean, safe water. Developers have identified nanotechnology as one of the most promising technologies for water desalination and purification. It can be used to kill the disease and bacteria before it enters the body.

We are at the Nano developments within the Nano technology field. There is amazing potential that could revolutionise medicine for years to come. It can save lives, change lives and most importantly, give advantage to the medical community in the constant battle against pathogens infecting our body, and our body itself, which statistically could prove more lethal than bullets. Continuing development is the only way to see if Nano technology will ever reach its potential, which is currently causing hype worldwide in the scientific community. As long as caution is taken along the road of development there is no reason why nanotech could not be the answer to numbers of diseases that kill millions of people per year. With almost endless potential, the future for Nano technology developments in medicine looks very bright, and only time will tell the true extent of the impact of nanotechnology.

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