

NANO SCAFFOLDING AND NANOTECHNOLOGY
RESEARCH INTO DIABETES

BY

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PASS WITH MERIT

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ABSTRACT

This paper will look at the role nano technology is currently playing in the field of medical research. Nano technology has a unique place in medicine as it allows researchers to intervene at an atomic scale. This paper will be focusing specifically on the research in nano scaffolding and its role in the cure for medical conditions such as diabetes, spinal cord injury, Alzheimer's and nerve damage in general. It will also attempt to review the ways in which nano technology is set to revolutionise the treatment of diabetes and the way it is controlled. Nano scaffolding in the future has the capacity to completely change the way heart attack patients will be managed, if nano scaffolding can be developed so that it can replicate damaged cardiomyocytes and be able to get them to beat in synchronisation with each other, it could greatly lengthen the life span of people who have suffered from myocardial infarction. . In diabetes the most viable way forward is for a nano silicon box to be made which would dispense genetically modified beta cells which would produce modified insulin. This modification would allow for insulin to only be dispensed when it is in the presence of glucose

INTRODUCTION

This paper will focus on nano technology and its increasing relevance to modern day medicine. Before going into depth about the strong connection between the two fields – nano technology and medicine - we must know exactly what nanotechnology is.

A nano metre is a billionth of a metre and one nano metre is about the size of three cells. Nano technology is based on the idea of imitating nature and working from the bottom up. It is about engineering functional systems on an atomic scale. It is a relatively new concept; however, it has very quickly grown in momentum as scientists have gained more knowledge about the field. The first ideas about nano technology came from Richard Feynman in 1959 when he gave a talk entitled 'there's plenty of room at the bottom'. Although, he did not mention nanotechnology, he was the first to bring up the concept behind it. It was not until 1979 when the Japanese Professor Norio Taniguchi wrote a paper entitled 'on the basic concept of nanotechnology' that the field was first named. The 1980s brought the invention of the atomic force microscopes created by Christopher Gerber and Calvin Quate. This allowed for matter to be manipulated at a nano scale. During the 1990s, fullerenes were discovered by researchers at Rice University.

Nano technology is beginning to have increasing relevance in many parts of different industries , the atomic scale in which it works, means that it is especially important in the advancement of medicine. With nano technology, in the future, doctors will be able to manipulate cell malfunctions at a cellular level, meaning that it can work with the body and emulate nature. This would mean that compared to tissue transplant, patients would react less vigorously to certain forms of treatment, most importantly prevent tissue rejection and need for immunosuppressive treatment.

This paper will look into the research happening regarding spinal cord injury, Alzheimer's and nerve damage. Spinal cord injury is when the spinal cord is damaged, caused by trauma. This may result in the patient feeling anything from experiencing pain to full paralysis. Alzheimer's is when tangles and plaques occur within the brain leading to the death of brain cell. Cures for these conditions are being looked at by scientist using new advances in nano scaffolding.

This paper will look at diabetes and the possible ways administrating insulin could be made a lot easier. Nanotechnology can play a vital role in revolutionising the way diabetics deal with their condition. Before examining the way in which nanotechnology can help to regulate diabetes it is essential to first examine what diabetes exactly is. Diabetes Mellitus is a metabolic condition where the body produces insufficient insulin or the cells do not respond to the insulin effectively resulting in high blood sugar levels. In individuals who do not have diabetes, the insulin produced by beta cells in the pancreas, binds to the receptor on the surface of cells. This insulin is what allows the glucose to

enter the cell. Excess glucose is stored as insoluble glucagon or fatty acids for later when the blood sugar levels drop. When the insulin is either not produced or the cells no longer responds to it, the glucose is left to circulate the blood. The body will attempt to dilute the levels of glucose in the blood by drawing water out of the cells and into the bloodstream. This results in glucose being present in the urine. At this time the cells are still being deprived of glucose, therefore the diabetics will feel hungry. In an attempt to extract glucose the body will start to break down proteins and fats into ketones. If the ketones remain in the blood they can cause a condition called ketoacidosis, which could lead to the diabetic falling into a coma or if left untreated, death. It is for this reason that ketones are also excreted and found in the urine. In the discussion we will examine how nanotechnology can be used to produce insulin and therefore regulate the metabolism of glucose.

DISCUSSION

Nano-scaffolds are used in the regenerating damaged tissue and bone cells. The damaged cells bind to the scaffolding and the cells reformulate through the holes of the scaffolding, after time the scaffolding is absorbed and disintegrates.

Nano scaffolds are essential to tissue engineering as it works in conjunctions with the stem cells to remake essential cells. Nano scaffolding is being researched into in depth as many leading scientist in the field believe it will play a vital role in the cure of spinal cord injury and Alzheimer's. In 2008 Dr. Nisbet from Monsah University did pioneering research into the uses of nano scaffolding technology. He found that by injecting the target area with the nano scaffolds and embedding the stem cell into the structure, the 3D scaffolds can manipulate the stem cells by providing the necessary structure to form the specialised cells required. On completion, the scaffolding breaks down and is absorbed causing minimal damage to the body.

Professor Bartlett and Jack Kessler did research into spinal cord injury. When spinal cord injury occurs the axon and spinal fibres are able to grow however, they are blocked by scar tissue. A gel was formulated that comprised of nano engineering. The gel inhibits the growth of scar tissue and provides the structure for the new cells to grow, by injecting the damaged area within the spinal cord with self-assembly scaffolding. The scaffolding not only inhibits the growth of scar tissue it also instructs the stem cell to produce myelin. Myelin protects the axon so that electrical currents are not distorted from one cell to another.

The next stage in nano scaffold regeneration is to be able to construct damaged cells within the heart as currently this has not yet been achieved. Myocardial Infarction (heart attack) leaves the sufferers with a weakened heart muscle caused by the death of the cells that were deprived of oxygen, from the blockage that occurred in one of the blood vessels. In 2010 Andre Levchenko did research into regenerating these cells. The success of a heart muscle is due to the synchronized contractions of the cardiomyocytes, however when he tried to replicate these cells in a petri dish he was not able to get the contractions happen simultaneously. Upon further research they realised that it was because there was a lack of alignment with the cells due to their disorganized growth. It is here that nanotechnology should be used in order to facilitate organized growth of the cardiomyocytes by providing a structure for the cells to grow. In further developments, nano scaffolding should be designed specifically for the patient in order for the new cardiomyocytes to be able to beat in unison with the patients existing cells within the heart. To prevent the patient having to receive extensive immunosuppressants due to the fact that there are foreign cells within the body, stem cells should come from the patient which would reduce the risk of infection after surgery.

Nano scaffolding is used in conjunction with stem cells and there are many moral issues behind using stem cells. Stem cells are totipotent embryonic cells, these cells are originally found in embryos. They are used because they have the ability to become any specialised cell and this concept is essential in tissue engineering. However many people believe that it should not be used as these cells come from embryos, and have the potential to become human being, therefore it is not moral to determine whether these embryonic cells become human beings or replacements for damaged cells. Essentially the argument comes down to whether it is moral to take life in order to sustain life. However, when looking at the extent that tissue engineering could impact the lives of millions of people it is hard to simply say that it is wrong to use embryonic cells.

Traditionally diabetics control their condition by having to constantly monitor their blood sugar levels and inject themselves with the appropriately dosage of insulin. This leaves room for error and can greatly inconvenience the everyday lives of diabetics. However scientists are beginning to look to nanotechnology to resolve the difficulties diabetic patients encounter trying to control their blood sugar levels through the administration of insulin.

In 1997 Mauro Ferrari from Ohio University and Tejal Desai from Boston University created a silicon box that will be inserted underneath the surface of the diabetic's skin. This cleverly designed silicon box is extremely small and contains pancreatic beta cells which produce insulin. It temporarily restores the glucose control feedback loop. The silicon box has nano sized pores typically around 20nm in diameter. This allows the glucose and insulin to pass through the pores but, it is too small to allow large molecules from the immune system to pass through, this prevents adverse antigen antibody reaction. This means that diabetics do not have to take immunosuppressant drugs the obvious advantage is that, they do not have to endure the susceptibility to infections that occur while receiving immunosuppressants. However, this idea still leaves room for improvement as the amount of insulin a person receives is very specific and can change depending on the dietary intake of the diabetic person or as the disease gets worse. Since this is ever changing the box will have to be replaced frequently depending on the diabetic person's condition.

Extensive research has been done into the possible applications for nanotechnology within the treatment of diabetic patients. Dating back to 1974 when scientist came up with an artificial pancreas. The idea behind it was that there would be a sensor electrode which would be placed into the patient, which would measure the levels of glucose within the body. This information will then be feed into a tiny computer that will calculate the number of units needed from a small reservoir of insulin. The problem with this idea was that, it was too large but with the advances that are being made in nanotechnology this problem could be solved. Medtronic MiniMed (research/ drug manufacturing company) has been working on a long term sensor system. This system like its predecessor links an insulin mini pump with the glucose sensor despite the research that has been done there are still setbacks; the scientists are having trouble developing the logarithm that translates glucose level readings into the correct dosage of insulin.

Despite the many appraisable ideas to make receiving insulin easier for diabetic patients, the most logical way is the SmartCell which was developed by Todd Zion. He has been able to reduce the endless calculation with his development. In his own words he described it as, 'when glucose rises in the bloodstream it will eat away at the smart cell structure. As the smart cell protein matrix breaks down insulin is released. The more glucose present, the faster the matrix will erode.' This is an

overview of how nano technology could revolutionise the industry. When it is looked at in great depth, it is surprisingly simple. It works by chemically modifying the insulin by binding it to biodegradable polymers which contain sticky sugar groups. It is then mixed in a solution of sugar binding molecules. As, more sugar binding molecules attach to the sticky groups a network forms which holds the insulin in place. In the presence of glucose the sugar binding molecule no longer bind with the sticky sugar group and instead binds with the glucose, when this occurs the network securing the insulin is broken which releases insulin into the blood stream.

The future of nanotechnology within diabetes lies in the combination of these three developments- that is, silicon box, artificial pancreas and the smart cell. The silicon box will work extremely well however it should be made of biodegradable polymers that degrade according to how long it will take for the beta cells to be dispensed. As oppose to just releasing beta cells you could release genetically modified beta cells that will produce modified insulin allowing the theory of the smart cell to take place. Nano sensory electrodes should also be used to detect when the box has degenerated so that diabetics know when to get their box replaced.

It appears that nanotechnology in medicine is a broad concept that needs to be fully explored.

CONCLUSION

In conclusion the future for nanotechnology is immense within medicine. In the fields outlined nano medicine is set to revolutionise the way conditions are dealt with. In diabetes the most viable way forward is for a nano silicon box to be made which would dispense genetically modified beta cells which would produce modified insulin. This modification would allow for insulin to only be dispensed when it is in the presence of glucose. Nano scaffolding in the future has the capacity to completely change the way heart attacks patients will be managed, if nano scaffolding can be developed so that it can replicate damaged cardiomyocytes and be able to get them to beat in synchronisation with each other it could greatly lengthen the life span of people who have suffered from myocardial infarction.

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