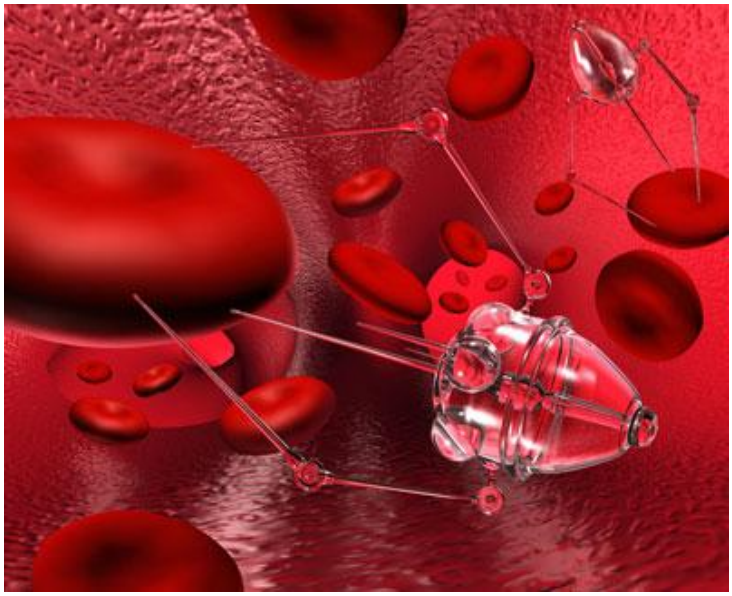
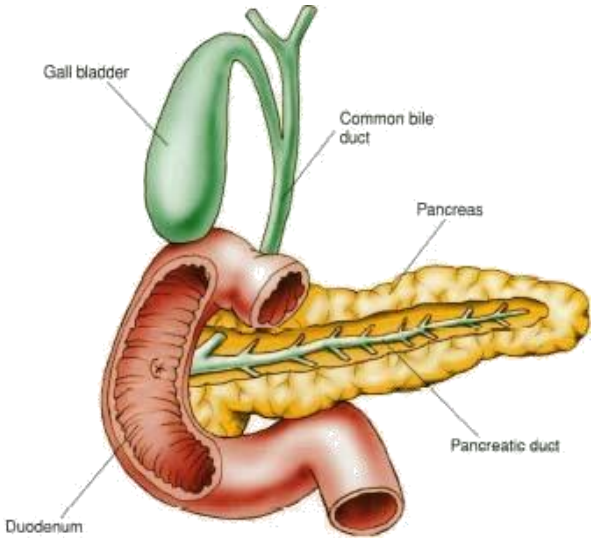
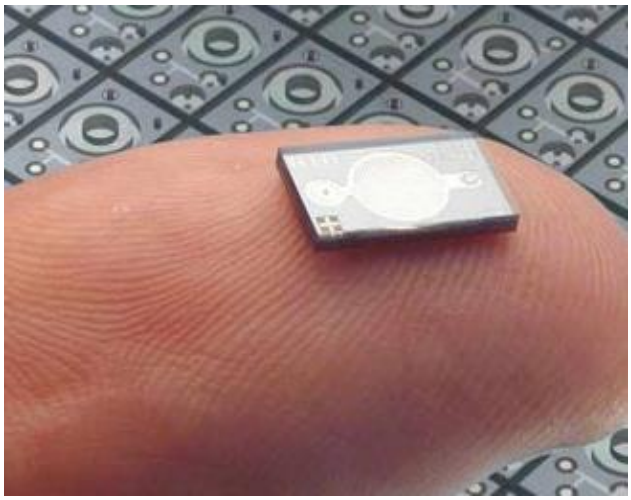
Nanomedicine: Could nanotechnology hold the cure for diabetes?







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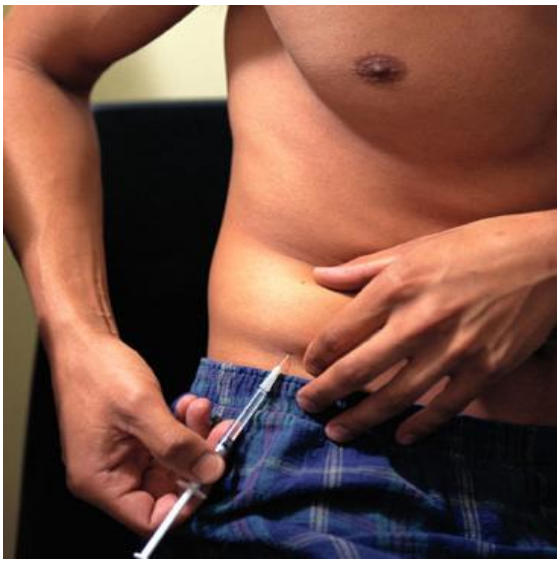
Introduction

This paper highlights one of the many possibilities of nano technology enabling us to further our knowledge about the human body and new ways of treating a disease hence changing the way we live and our futures.

This science paper specifically highlights the advances of nano medicine within the field of diabetes. As world population increases, greater resources are needed to sustain society. An alternative to this issue is to be highly efficient; this could be achieved through nano technology.

Diabetes is a disease which causes a patient to have high blood glucose levels, this can then lead to further complications if not treated resulting in organ damage and in extreme cases death.

Diabetes is caused in two ways, firstly there could be a problem with the pancreas, the pancreas is unable to produce enough or no insulin hormone at all and therefore the liver is unable to store the sugar in fat cells in the form of glycogen. The second way of forming diabetes is due to the body's cells becoming resilient to the body's own insulin hence unresponsive in the presence of insulin, this could be caused by antigen variation or a hormone resistance a change which is caused by genetic coding.



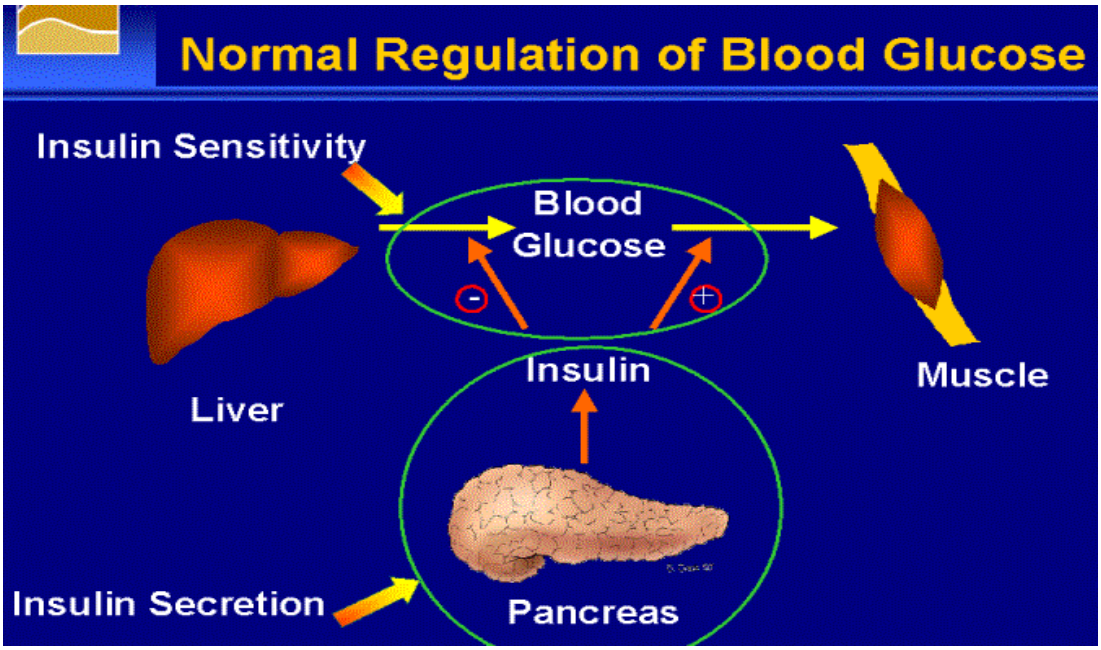
Diabetes is categorised into two groups: Type 1 and Type 2.

Type 1 diabetes affects around 15% of all diabetics most of whom are under the age of 40 and is most common in young children. It can be present from birth or child hood with the only effective treatment being via regular injections of insulin before meals. It can't be administered orally otherwise the stomach acid denatures and digests the hormone. The injections can be painful and can cause a hindrance in every day aspects of life. Patients who use insulin injections find they gain weight rapidly which can affect a patients mental well being, this can be more predominant in young women who become insecure about their weight some even entering cycles of depression; yet it is a crucial step for them to survive.

Without insulin the patient finds it hard to heal from physical wounds, the increased amount of sugar in their blood dehydrates the body as the kidneys are unable to absorb as much water, hence the constant feeling of thirst. The patients' vision becomes blurred and experience fatigue as the body has no reserve of sugar stored in the body, all excess sugar is lost in the urine causing severe weight loss.

Type 2 diabetes affects about 85% of all diabetics and is most common in the white population and more prevalent over the age of 40 in the white population and over the age 25 in black and south Asian communities. The severity varies from patient to patient.

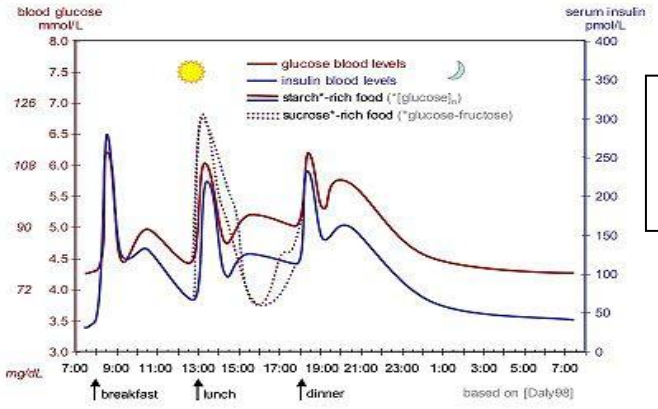
Patients with type 2 diabetes can either manage their diabetes through carefully monitored diets of low carbohydrate sugars and starch foods as the body would still produces some insulin but production isn't at maximum capacity, for those who are unable to control their diabetes through diet alone they are required to use tablets such as metformin. Although a slight hindrance to a normal way of life the impact is minimal in comparison to regular injections of insulin which the more sever sufferers must take in order to survive. The symptoms of both types of diabetes are the same.



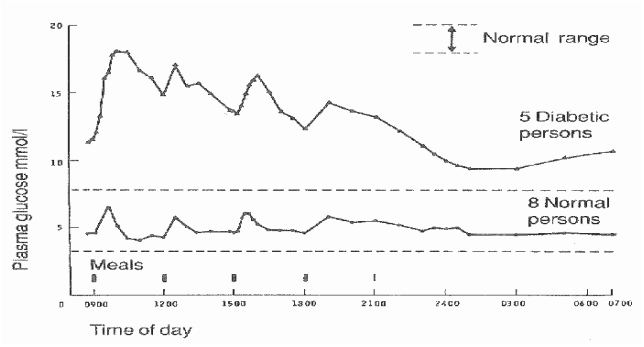
Insulin

The link between diabetes and insulin was discovered by the famous scientists Banting and Best in 1921 this discovery lead them to winning the Nobel Prize. Up until 1978 insulin extracted from cattle and pigs were used but this was inefficient as production didn't meet the demands for the hormone there was also the problem of rejection as the insulin came from cows and pigs hence it wasn't a compatible as human insulin, so in 1978 scientists transplanted the human gene for insulin into a rapidly growing microbe plasmid and then artificially synthesised human insulin at a rapid rate hence curing the problem of rejection and producing enough insulin to meet demands. This is considered to be one of the first steps towards nanomedicine. It was one the most successful pioneering starting points for DNA engineering.

Yet injecting insulin has its own problems, a healthy person's body produces the correct amounts of insulin to the amount of blood glucose levels adapting and changing continuously to maintain a constant level all the time however a diabetic on the other hand goes through several peaks and troughs throughout the day as their insulin levels and blood glucose levels can't be monitored all the time.



A graph showing the blood glucose levels of a patient suffering from diabetes using insulin injections:



A comparison of glucose levels in the blood between a healthy person and a person suffering from diabetes.

The effects of diabetes directly doesn't impact the health of a person's body but the disease is considered as a contributing factor to diseases such as stroke and heart disease which are two of the world's biggest killers but also some other crippling diseases such as kidney failure, high blood pressure and even blindness.

Diabetes is considered to be large factor of ill health in the USA and is linked with 200,000 deaths per year on average. In third world countries where healthcare and basic human amenities are compromised the number of diabetic deaths are much higher, this is more predominant in countries such as India and Africa due to starvation and malnourishment The reasons of practicality and a need for new methods are required to deal with the worlds growing population and for the longer living westernised population. Hence nanotechnology is expected to deliver the newest forms of diabetic treatments with more efficiency and more effectiveness. If nanotechnology does find a more effective treatment method to diabetes, billions of pounds could be saved in the countries with the technology as there will be a drop in the number of diabetes related diseases and so the state funding will become more resourceful in other areas, nations with poverty zones may also find the answer in nanotechnology as it would mean fewer deaths per year and less money spent helping against diabetes due to the more effective health care.

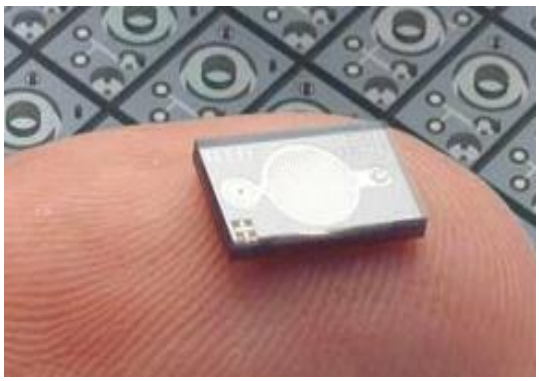
The main problem for scientists was the fact that insulin could not be taken orally and had to be injected directly into the blood stream, they produced an insulin pump the size of a mobile phone which could continuously monitor the blood glucose levels and inject accordingly, this was produced 6years ago. Yet this is still a hindrance as it is large and obvious it is also restrictive when patients play sports and could easily be damaged or pulled loose. A wire is always connected to the patient and this could be quite distressing for young active patients as they may feel embarrassed. There is also a slight chance of cross infection as the tube provides a opening into the body.

Insulin pump:

Another option scientists were considering was a spray which could be taken as a inhaler, this would allow insulin to be absorbed through the lungs and directly into the blood stream using nano particles which could quickly and easily defuse into the blood stream but the patient would still be bound to using regular doses and if accidentally forgotten the patient may become hyper or hypoglycaemic depending on their condition.

The latest advance in this field of research is the nano-insulin pump. A small capsule the size of a tiny silicon chip containing pancreatic cells is created. It has micro pores which allows the squamous red blood cells and other small molecules into and out of the capsule but doesn't allow larger cells such as phagocytes, antibodies and other immuno-responsive cells and proteins to enter hence keeps the pancreatic cells inside safe from danger but also provides nutrients and allows them to release insulin according to the amount of glucose in the blood at that particular moment. The tiny pump to be mounted on a disposable skin patch to provide continuous insulin infusion to diabetic patients or underneath the skin**.**

With this new technology diabetics will be completely free from regulations in diet and the restrictive systematic regime. They will no longer be dependent on insulin injections and their blood glucose levels will be adjusted accordingly to the patients glucose level at that moment in time. This would enable the patient to lead a normal life. The benefits would be especially useful for the young who are always active; this would allow them to feel like a person without diabetes. The unhappiness diabetics would feel with the fluctuating weight gain especially during teenage years would be diminished and help the patient feel more mentally secure and confident amongst their peers .



Other alternative treatments: pancreas transplant

The current alternative to insulin injections is a pancreas transplant but there are many side effects and complications associated with this type of treatment. As this is organ donation the patient is put on a waiting list which usually entails a very long waiting period and could take years, sometimes too late for the patient. There are other factors adding to the problem of the long waiting lists such as cross matching tissue, this is so that the donor organ and recipient are a match so that the body does not reject the organ. Following the operation the patient would also be required to use immune suppressant drugs, leaving them susceptible to hospital viruses such as the H1N1 super virus. With all these factors the success rate of the transplant are around 90% giving the patients freedom from insulin dependency. The organs can approximately function up to 10 years after surgery, it is then estimated that only half the transplants are expected to continue working successfully. However the intended success rate of the nano pump is anticipated to be 100% this is because if it stops working it can be easily replaced and there is no need for open surgery hence minimal risk.

The new ST-enabled Debiotech miniaturized MEMS device is about one quarter the size of these existing pumps and can be worn as a nearly invisible patch on the skin. The small size frees the patient from concerns with holding the pump in place and concealing it under clothing.

The MEMS-based Nanopump also provides better control of the administered insulin doses. Dosing precision is a critical factor in treatment efficacy and contributes to reducing adverse long-term consequences. The Nanopump is able to control delivery at the nanoliter level, very close to the physiological delivery of insulin. The device prevents over-dosing and detects under-delivery, occlusion, air bubbles and other potential malfunctions in the pump to further protect patients.

As a disposable device, manufactured using high-volume semiconductor processing technologies, the MEMS-based Nanopump will also be much more affordable, allowing the patient or the health system to avoid the typical up-front investment associated with current pump solutions. **(article taken from Nano technology site listed below)**

Ethics of nanotechnology: Good vs. Evil

As with every new scientific breakthrough there is always an ethical side to the story. The pump must be tested on animals before trialled on humans. Some may say that only the rich and developed countries would be able to fund this kind of technology for their citizens and the poorer nations will be robbed of the chance of being equally treated to those who are wealthy. Others may be worried that the nano technology may open flood gates for a nano-war with nations having the ability to create smaller viruses and lethal toxins used in biological warfare such as the already fears of anthrax attacks. In recent years a technology race has been triggered, hostile nations have begun to develop new technology and have tried to start "cyber war" so what is to stop any of them using the latest nanotechnology advancements for evil instead of good if in the wrong hands. These are the many fears that people feel are associated with nanotechnology. Further in this paper I have accentuated each area with details supporting for and against the argument: "Is nano-technology safe?"

Animal testing

Animal testing is necessary to show the true potential of a drug, the drug may have different effects in different classes of animals so it is necessary to test on animals. The true side effects can only be identified if tested on animals. Through the potential suffering of one animal many lives can be saved and in the eyes of a scientist this small lose out weights the life saving potential. Scientists only experiment on animals after first running through many procedures, through computer simulations and the effect of a new drug on live tissue before moving onto organs then animal testing, this minimises the number of mistakes and insures the animal doesn't endure unnecessary pain.

However in some cases such as HIV, the animals may not have the disease naturally and therefore purposefully infected, this can be perceived as barbaric and unnecessary. Animals could die through testing and some are left severely ill.

Political powers and war,

Some countries may try and use the pioneering technology as a tool for political supremacy by way of biological warfare; this could trigger unrest between neighbouring countries arousing suspicion and civil unrest. This may encourage other countries to design such products through claims of national defence. Many fear this could lead to a repeat of history.

Rich vs. poor

Only rich nations would be in a position to develop and trial such technology as their infrastructure would be more stable. This could lead to a further divide between the rich and poor nations. Many people could die due such a divide as poorer nations could not afford to pay for such treatment.

What are the long term effects of nanotechnology?

No one knows what the long term effects of such technology can be although all the clinical trials are completed thoroughly, they are not completed over decades and any side effects could emerge much later over a long period of time.

Religion:

Many religions see an illness as an act of god and that if god has decided this, no one has the right to act as god and create a cure. Many see that creating technology is going against the will of god and as a human we have no right to this power. However many religions also believe that there is no greater gift than the gift of life and would this then suggest that certain measures could be taken to preserve that life.

Who is the true winner in the nano-race??

The most important winner is the patient receiving this treatment, followed by the pioneers, but many feel that the stakeholders and government see this not as a life saving cure but another investment and gate way to yet more riches hence making the rich, richer and the poor, poorer. It is clear that nanotechnology will spark a revolution but its scientific potential is marked by those out to reap profits. As one industry rises another falls, if the insulin pump becomes a success then diabetics will no longer be dependent on the insulin produced by huge companies and so there will be huge adverse affects as companies close, people will lose their jobs and yet new jobs will be created in the process and so the equilibrium is maintained.

Conclusion

In conclusion I believe nanotechnology is the right way forward in particular nanomedicine and the insulin pump. Although the negatives, of the loss of animal life through animal testing is unfortunate the positives outweigh the negatives giving many the freedom to live a full life without restrictions giving them freedom from their illness. It will save millions of lives worldwide and also support the current economic situation. The insulin pump will reduce the number of diabetics requiring hospital treatment consequently the number of insulin dependent patients will reduce drastically saving millions of the NHS funding. Nano technology is also proving to be cost-effective in other aspects as it requires fewer resources but with a much more effective outcome. Efficiency is essential as the world population increases; economical efficiency is the most stable way of supporting the billions of patients with diabetes.

Conclusively I believe the advantages of nanotechnology and the nano pump greatly outweighs the disadvantages and therefore would be recognised as a valuable breakthrough in science and medicine.

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"This paper has derived from my own personal experiences of diabetes through having three family members who suffer from this illness and I have seen the day to day barriers this disease can pose on their lifestyle & wellbeing."

Information and images obtained from the following sites

http://www.netdoctor.co.uk/diabetes/treatments/control_blood_sugar_001903.htm

http://unesdoc.unesco.org/images/0014/001459/145951e.pdf

http://www.crnano.org/whatis.htm

http://www.debiotech.com/

http://www.battlediabetes.com/diabetes-nanopump

http://www.diabetes.org.uk/Professionals/Publications-reports-and-resources/Reports-statistics-and-case-studies/Reports/Diabetes-in-the-UK-2010/

http://diabetes.niddk.nih.gov/dm/pubs/statistics/#fast

crusader888.blogspot.com

http://www.bidmc.org/CentersandDepartments/Departments/TransplantInstitute/Pancreas/FAQ.aspx