Encapsulation of Cells in Microporous Annealed Particle Hydrogel for Type 1 Diabetes Treatment

Building Transparency in the Scientific Community

Sociotechnical Synthesis

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On my honor as a University Student, I have neither given nor received authorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Biomedical research has been progressing at an explosive rate in recent decades. Modern technology and knowledge let us conduct research on everything from cancer therapeutics to life-saving medical diagnostic tools, to muscle regeneration treatments, to genetic modifications and engineering, and so much more. Type 1 diabetes (T1D) is caused by the autoimmune destruction of the insulin-producing islet cells in the pancreas. T1D patients can administer exogenous insulin to regulate blood glucose fluctuations, however, insulin is expensive and incapable of fully restoring glucose regulation functionalities. The global cost of medical care for diabetes in 2015 was $1.3 trillion US dollars,[1] and is expected to surpass $2.1 trillion by 2030. Insulin detemir (IDet) is a commonly used treatment for type 1 and type 2 diabetes that lasts for only *24 hours*, despite the retail price for five syringes is $146.99.[2,3] This is not a cost that can be easily afforded by all people. Therefore, there is a clinical need to develop a long-term treatment for T1D that can restore endogenous insulin secretion and be afforded by all people, regardless of socioeconomic class. However, we need to be sure that we develop a treatment that not only will prove to be safe and effective but will be trusted by the targeted population.

Technical Project

Hydrogel encapsulation is a promising method to protect islets from a diabetic immune system, though the lack of porosity and tunability of hydrogels is known to inhibit the ingrowth of supporting vasculature.[4] The technical portion of this thesis aims to create an alternative treatment to T1D that allows for the recovered functionality of insulin-producing beta cells.

Microporous annealed particle (MAP) gel is composed of highly concentrated hydrogel microspheres that are assembled *in situ* and covalently bonded to form a porous macroscale material.[5] Beta cells can be dissociated from islet cells and encapsulated within MAP hydrogel microspheres using microfluidic devices, and the resulting porous scaffold allows for ingrowth of blood vessels to promote long-term cell viability.[6] Doing so will allow for the sustainable and autonomous production of insulin after treatment, without the need for daily expensive injections of insulin that fail to recover the body's inability

to produce insulin. The objective is to create a therapeutic that will regenerate insulin-producing cells in diabetic patients and restore the ability to autonomously produce insulin.

Over the course of our Capstone project, our team was able to successfully optimize the MAP gel polymer solution as well as microfluidic flow rates to create a hydrogel capable of cell encapsulation and cell viability maintenance. We were able to encapsulate a variety of cells as a proof of concept, including mouse embryonic fibroblasts and human dermal fibroblasts. We were able to maintain a certain level of cell viability in the encapsulated cell over the course of 4 days, and we have begun experimenting with different procedures to freeze the cells and retain viability after thawing.

STS Research Paper

In spite of the success of numerous novel engineered therapeutics to provide solutions for a variety of biomedical problems, there will always be a number of ethical and safety concerns surrounding the use of cell therapies, biomaterials, tissue engineering, or anything deemed "unnatural" to a lay person. There is a plethora of myths about developments in the science and engineering industry. Particularly targeting the SARS-CoV 19 pandemic, when the first vaccines were being released, many were concerned by the abbreviated time period it took for the vaccines to be approved, in spite of every vaccine having to check all of the boxes before being distributed. People thought that the mRNA vaccines would change DNA and result in cancer, they thought it contained toxic ingredients and would lead to worsened health.[7]

During my STS research, my goal was to better understand the concerns, investigate how they began, and figure out how to resolve these issues in order to induce higher vaccination rates and improve the safety of the general public. This research primarily supports the idea that lower levels of education were correlated with lower rates of vaccination, with lack of high school education as one of the top indicators of vaccination hesitancy.[8,9] It was found that many in the unvaccinated population did not understand the level of concern and danger presented by SARS-CoV 19, indicating that the science community failed to emphasize the seriousness of the pandemic. The main conclusions drawn from this research indicate that in the future, the science community must improve their delivery of information and

education in order to better communicate medical issues that may not be easily digested by someone lacking a higher level of education. While doing so, we may hopefully be able to improve our preparation and handling for any future situations.

Conclusion

The synthesis of my technical and STS research projects emphasizes the importance of consistently pushing towards novel research to benefit science and humanity, while keeping in mind the ethics of biomedical research and considering those whom we are aiming to help. It is important to remember that while we can develop innovative treatments to diseases, it would all be without purpose if the population we are trying to help is distrustful of new therapeutics.

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Resources

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