Implantable Scaffold for Bone and Cartilage Tissue Regeneration in Arthritic Patients

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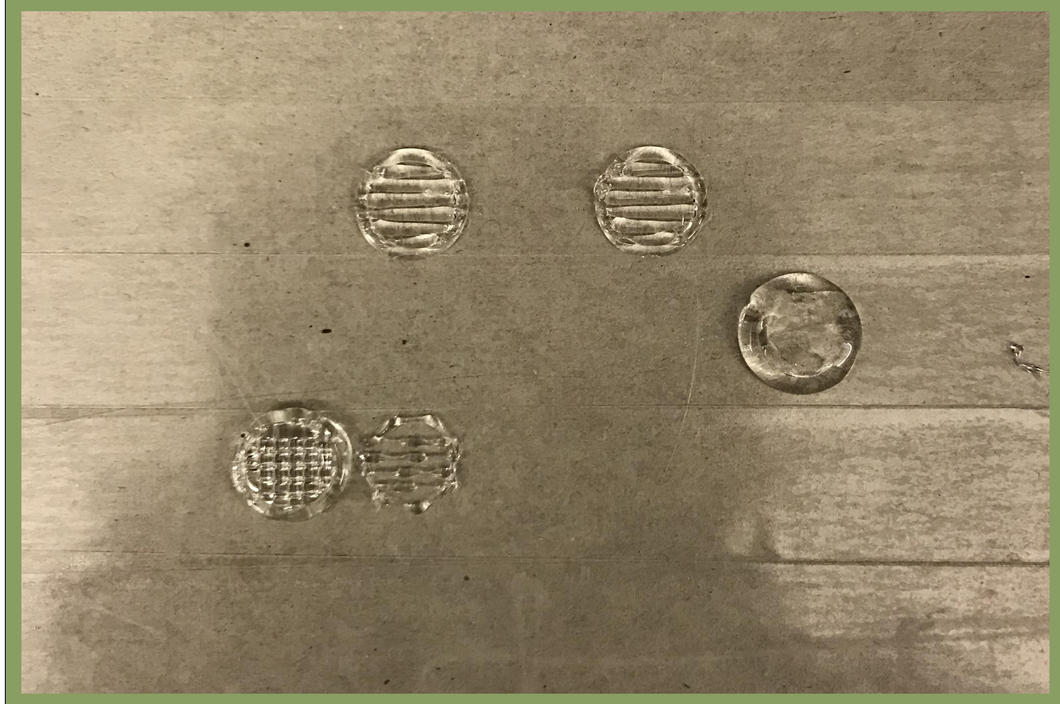
Introduction

In Spring of 2019, I began working with Dr. Robert Choe at the Fisher Tissue Engineering Lab at the Fishcell Department. We began working on a biomolecular construct to aid in the therapy of arthritic patients. The device is a scaffold comprised of three layers: a bone layer, a cartilage layer, and a layer that joins the two. The scaffold supports the adhesion of osteogenic and cartilagenic stem cells. When placed within a patient, the scaffold would be able to amplify the regeneration and healing processes of damaged tissue.



A number of scaffolds that I printed under varying parameters such as print speed and print temperature.

Site Information:

-University of Maryland Fischell Department of Bioengineering: Fisher Tissue Engineering Lab

-3102 A. James Clark Hall, College Park, MD 20742

-Supervisor: Robert Choe, DDS

-Department Mission: “The Fischell Department of Bioengineering is a forward thinking academic organization dedicated to utilizing engineering and scientific knowledge and methods to assist the citizens of Maryland and the nation. The department intends to develop biologically based knowledge and products to promote ecological, human, and animal health, and to improve the quality of life while maintaining a healthy environment. The department aims to quickly assume a leadership role in the field of bioengineering through educating an innovative student body and pioneering groundbreaking technologies.

-Fisher Tissue Engineering Lab Mission: “Biomedical engineering; synthesis of novel hydrolytically degradable; implantable polymers; study and use of biomaterials for the delivery of therapeutics; scaffolds for orthopaedic tissue engineering applications; interaction of biomaterials and tissues

Image from Ballinger (http://www.ballinger.com/portfolio/umcp_clark_hall/)

Tasks (among many others):

1. Cell Culturing

   One of my primary duties was culturing all mesenchymal stem cells used in experimentation on the scaffolds. I learned how to culture multiple types of cells, to culture cells on scaffolds, differentiation, and many other related techniques.

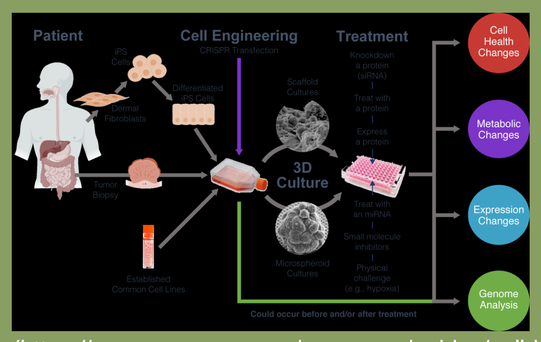


Image from Promega (https://www.promega.com/resources/guides/cell-biology/3d-cell-culture-guide/)

2. Microscope Imaging

   Another primary responsibility of mine was microscope imaging. I learned a number of imaging and staining techniques, such as immunofluorescence microscopy, that allowed us to ascertain the success/failure of experiments.

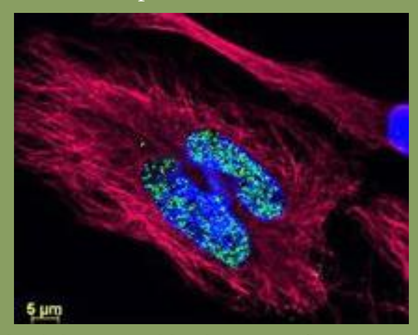


Image from Rockland (https://rockland-inc.com/fluorescence_microscopy.aspx)

3. RT-PCR

   To ensure that the scaffolds were properly functionalized and induced the proper reaction from hosted cells, RT-PCR was another task I was responsible for completing very regularly. Cells that are hosted properly express specific genes that can be examined following RT-PCR.

Impact & Future Work:

Although lots of great progress has been made, the project is certainly far from over. Although many obstacles have been overcome, such as development of 3D printing protocol and scaffold material that is able to host cells and resist degradation, the bone-cartilage scaffold is still not ready to be used in clinical care. This is largely due to immunology. It is extremely difficult to deliver foreign substances into the human body long-term without triggering a response from the immune system. The current scaffold, if placed within the human body, will be devoured quickly by monocytes, macrophages, and osteoclastogenesis on behalf of the immune system. The future of the project, consequently, largely involves being able to accommodate the scaffold to satisfy the immune system, or, in other words, how to ‘trick’ the immune system into not destroying the construct. Having learned so much during this experience regarding tissue engineering and the different research that is being done in my preferred field, I decided that I will be continuing this project with the goal of examining how different levels of scaffold stiffness and surface treatments effect the degradation of bone. It is known that both of these parameters play a role in the homeostasis of osteogenesis (bone formation) and osteoclastogenesis (bone resorption). By examining the effect of these parameters on the balance of construction and destruction, lots of progress can be made in the ideal design for such scaffolds. This will ultimately bring the scaffold closer to fulfilling its intended purpose of aiding patients suffering from arthritis. I hope to use the many new techniques that I was trained in, such as 3D printing and scaffold functionalization, to investigate this interesting subject.

Acknowledgments:

-Dr. Robert Choe for supervising me, training me, incorporating me into the lab as well as his various projects

-Dr. John Fisher for the opportunity to work with him in his lab and for guidance on projects

-Dr. Thomas Holtz and Dr. John Merk for encouraging me, as well as other SGC students, to seek out relevant STEM experience through the CPSG program