Thesis Project Portfolio

Microdevice Enabling Long-term in Vitro Study of Biofabricated Constructs

(Technical Report)

Comparing Animal Models and their Alternatives: Examining Ethical, Regulatory, and Technical Perspectives

(STS Research Paper)

An Undergraduate Thesis

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My technical project was to design and fabricate a device that would stabilize hydrogel microparticles (HMPs) for long-term in vitro studies. This would allow researchers to harness the unique properties of granular hydrogels, which are water-swollen polymer networks used in research to mimic tissue due to their high water content. Hydrogels have a wide variety of applications, ranging from contact lenses and wound dressings to tissue engineering and drug delivery systems. A subset of these hydrogels, called granular hydrogels, are composed of HMPs and can be produced by various techniques that control the size, shape, and properties of the resulting granules. Granular hydrogels have unique properties, allowing them to be injectable, self-healing, and promote vascularization. However, due to their non-crosslinked nature, HMPs are dynamic, unlike bulk hydrogels, and have a tendency to erode during cell culturing, leading to material loss and microstructural degradation.

To address these issues, our team developed a device that facilitates the exchange of nutrients and waste during cell culturing while still containing the HMPs. The device consists of four main elements: the lid, base, mesh, and coverslip. The base has wells where the HMP-based material can be deposited. A piece of mesh is inserted and sits above the wells, confining the particles while still allowing liquids to pass through. The lid fits atop the base, trapping the mesh between the two pieces, and has through holes that line up with wells, allowing media to be introduced. Finally, there is a glass coverslip bonded to the bottom of the device to allow for precise imaging.

This device ensures that the material is contained within the system while still allowing for cell-culturing techniques that would have otherwise eroded the granular hydrogel. Furthermore, the base and lid design allows for modifications to the material at any point in the experiment. This could allow for bioprinting within the material system to further recapitulate

tissue. Ultimately, this device could become a standardized tool for researchers to more accurately mimic tissue and study diseases.

My STS research was a technical, regulatory, and ethical comparison of animal models and their alternatives. This was further analyzed using Latours Actor-Network Theory to compare these areas with respect to the networks of animal models and its alternatives. Throughout history, animals have been considered the gold standard of test subjects because of their analogous physiological systems, biological similarities, and accessibility. Animals are considered a highly efficient means of testing therapeutic drugs for any adverse effects and can be used to mitigate health risks to humans. While animal testing has been invaluable in the past, rapidly advancing technologies such as biomaterials, synthetic tissues, and computation models are enabling more accurate representations of human tissue. In turn, this may reduce the reliance on animal testing and present new options for drug testing and research.

We broke the research into two major sections, each following an identical format, but one for animal models and the other for alternative models and methods. It begins by addressing the topic broadly before diving into some of the relevant histories for both aspects of this comparison. Despite the fact that animal models have been used throughout history and many of the alternatives are less than a decade old, it serves as a foundation for the comparison. From there, we break into each section of the comparison, beginning with the technical capabilities of each. Animal models provided a tried and true means of testing while its alternatives showed promise of rapidly improving technology but without much to back it up. From a regulatory standpoint, there is an abundance of regulation regarding animals and their use; but there are still some concerns for animal welfare. There has been an increasing number of bodies regulating

alternative models and advocating for their use and continued development. The ethical dilemma appears most cut and dry favoring the use of non-living alternatives to animal models, however, there still remain some concerns.

Based upon these analyses, we attempted to demystify the networks and see the commonalities between the two as well as the stark differences. Despite the challenges and controversies surrounding the use of animal models in research, their contributions cannot be denied. However, as science progresses, we must continue to question the validity and ethics of our practices. Alternative models may offer viable alternatives to the use of animals in research, but their technological advancements do not necessarily equate to superior testing results.