Executive Summary

The healing of musculoskeletal tissues such as tendons and meniscus is a critical area of orthopedic research, with tissue culture playing a central role in developing regenerative treatments. The Shiley Center for Orthopedic Research and Education (SCORE) Lab sponsored the development of a biomechanical stretcher machine capable of applying cyclical tensile and compressive strains to engineered tissues in vitro. This system was designed to simulate physiological loading environments, fostering the growth of functional cell matrices in tendon and meniscus samples. The reactor is designed to be fully operable within a standard laboratory incubator, using off-the-shelf containers and prioritizing sterilizability, modularity, and ease of use. The system delivers controlled 1 Hz cyclic loading at 10% strain and up to 20 N of force, satisfying the primary biological requirements for tissue stimulation over a two-week experiment. The device integrates key parts including an aluminum base plate, a lift plate that is easy to remove, a SMAC linear actuator for precise actuation, and interchangeable clamping systems for both tensile and compressive loading. The tension clamp system, iteratively prototyped and manufactured, reliably secures collagen specimens, while compression is delivered via a scissor-style or peg-and-hole clamp configuration. A load cell integrated with LabVIEW provides real-time force feedback, while quick-release IMAO clamps allow for easy disassembly of the lift plate and other components and sterilization. Handles enable easy transportation of the lift plate for changing solution media. Compared to commercial systems like ShellPa Pro, the team's design improves stability, ease of use, and scalability, while reducing cost by using rigid, disposable trays and improved mechanical alignment via machined rails and fasteners. Furthermore, a simple lid design is placed on top of the area where tissues and specimens are undergoing experimentation to prevent any dust or particles from falling. Preliminary testing showed consistent actuation and forces of 18 N with minimal system friction, validating the system’s capability to maintain desired loading parameters. Future directions include implementing more advanced control software, improving nutrient feeding robustness, and refining compression clamp design for enhanced biological relevance. This system stands to significantly aid researchers in developing synthetic cell therapies by providing a controlled and

customizable mechanical environment for cell culture, accelerating the translation of orthopedic tissue engineering from bench to bedside.

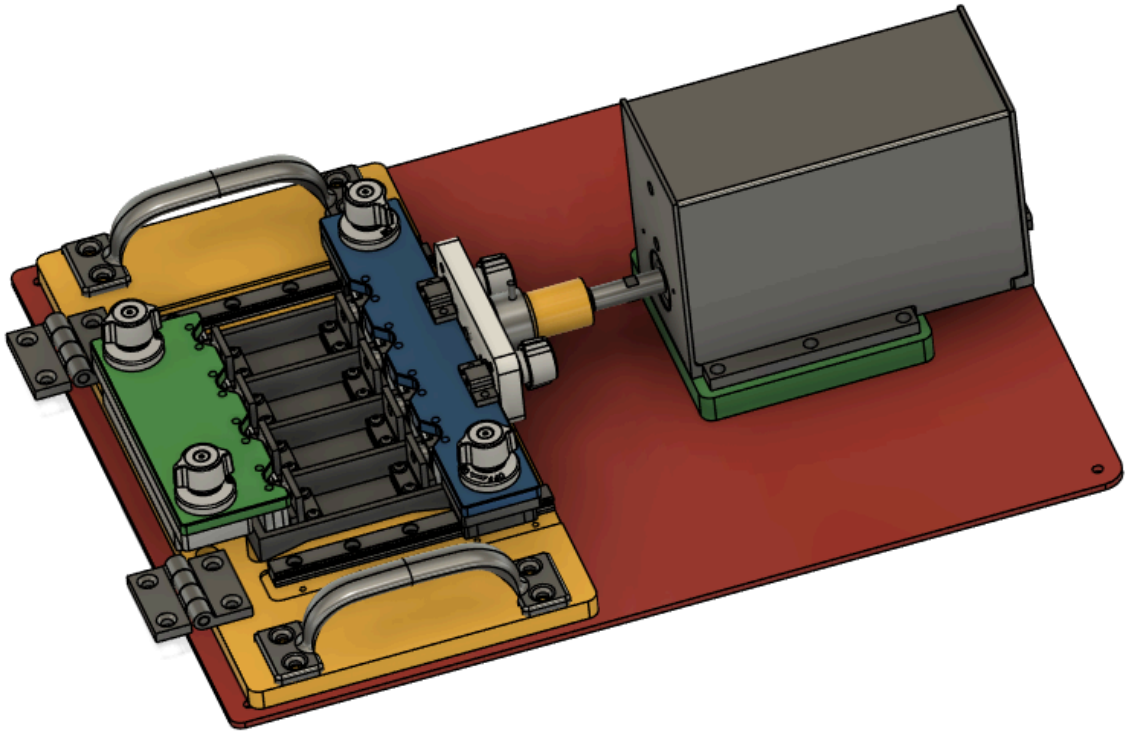

Figure E1: CAD of existing final prototype iteration