Samuel J. Laurencin
Title: **Fiber-reinforced, anisotropic superporous cryogels for meniscal replacement**

Advisor: Prof. Giuseppe Palmese
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Menisci are anisotropic, semicircular fibrocartilaginous tissues that must withstand extensive loads and sustain adequate locomotion in the knee joints. Meniscal tears are the most common intra-articular injury affecting the knee joint and consequently are the most common reason for procedures performed by orthopaedic surgeons. Once damaged, the partially vascular tissue has limited self-regenerative capabilities. Gold standard treatment of meniscal tears involves controlled excision of the damaged area, which exposes more of the underlying cartilage to increased contact pressure and increase the risk of early onset osteoarthritis.

Currently, there is a critical need to develop a biomaterial that is firm enough to resist the high, anisotropic loads the menisci experience and can permit fixation to the rigid underlying bone, yet soft and lubricous enough to protect the cartilage it interfaces and allow for normal joint locomotion. Polyvinyl alcohol (PVA) cryogels are water swollen polymers (hydrogels) that undergo low temperature-induced physical crosslinking and have been proposed as a meniscal replacement due to their biocompatibility, low coefficient of friction and compressive strength, which can be tailored to match native menisci. The hydrogel's mechanical capabilities are limited by its tensile strength being much lower than the meniscus. Fixation of a water swollen polymer into the joint space is also a challenge that must be addressed for the scaffold to restore normal joint mechanics.

Through this research, it was demonstrated that ultra-high molecular weight polyethylene (UHMWPE) fibers could be introduced into a PVA cryogel in a controlled fashion using a coupon system. The interfacial shear strength between the fibers and cryogel were optimized using a 2-step process utilizing plasma oxygen deposition and a glutaraldehyde covalent linkage. The presence of UHMWPE makes the cryogel anisotropic with respect to compressive and tensile strength, consonant with the native menisci. A liquid-liquid phase separation technique was employed to create a second PVA phase with an interconnected superporous network to aid *in vivo* implant fixation through cellular infiltration along the scaffold periphery. The structural and functional properties of the superporous PVA can be dictated by the synthesis parameters and influenced by post-synthesis osmotic conditioning. Transport properties through the cryogel was also established. Finally, the two-phase, tri-component cryogel was successfully scaled-up from the coupon system to native meniscus dimensions. This work provides great insight into the structural and functional features of fiber-reinforced, superporous cryogels and advances the field of biomaterials closer to a viable nondegradable meniscal replacement.