Dynamically Tunable Hydrogels for Vascular Stiffness Modulation

*Hydrogel-based matrices are widely used to model the physical microenvironment of cells in engineered tissues. However, most current systems rely on **static materials with fixed mechanical properties**, limiting the ability to study how cells respond to mechanical changes over time. In native tissues, extracellular matrix properties such as stiffness evolve dynamically, influencing cell behavior, barrier function, and mechanotransduction.*

*In this project, you will develop **phenol-modified hydrogels with controllable crosslinking and stiffness**. Phenol-functionalized polymers enable enzymatic crosslinking reactions that allow the degree of crosslinking, and therefore the mechanical properties of the hydrogel, to be adjusted over time. By tuning crosslinking conditions, the material can undergo **controlled stiffening after gel formation**, creating a dynamic matrix whose mechanical properties can be programmed during experiments.*

Some tasks will involve:

- *Tune enzymatic crosslinking conditions to control gelation and stiffness.*
- *Characterize hydrogel mechanical properties using rheology or mechanical testing.*
- *Develop protocols for inducing controlled stiffness changes over time.*
- *Test compatibility of the hydrogels with endothelial cell culture and perfused channel systems.*

*The resulting platform will enable **dynamic control of the mechanical microenvironment**, which can be used to study how vascular cells respond to changes in matrix stiffness. Such systems may also serve as **in vitro models to investigate processes associated with arterial stiffening**, which are difficult to capture using conventional static materials.*

See *- R. Schnellmann et al.,Stiffening Matrix Induces Age-Mediated Microvascular Phenotype Through Increased Cell Contractility and Destabilization of Adherens Junctions, Advanced Science, 2026*

J. Stanny et. al. – Geometrical designs in volumetric bioprinting to study cellular behaviors in engineered constructs. Advanced Healthcare Materials, 2025.