Department of Biomedical Engineering
UNIVERSITY OF WISCONSIN–MADISON

Spring 2024 Seminar Series

Engineering Biomimetic Materials for Female Reproductive and Gynecologic Health

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Female reproductive and gynecologic health are historically understudied fields that would significantly benefit from engineering expertise due to the unique biomechanical environment in the female reproductive tract and the dynamic tissue changes orchestrated throughout the menstrual cycle by sex hormones. With the synergistic techniques of tissue engineering, biomaterials science, biomechanics, and reproductive biology, we engineer models of the female reproductive system, including the endometrium, decidua, and vagina, to study pregnancy-related disorders and birth injuries. We use these tissue engineering models to understand cell-cell interactions, cell-matrix interactions, and hormone dynamics in the context of early pregnancy and vaginal tearing during childbirth. To mimic, instruct, and define the cellular microenvironment in the female reproductive tract, we use gelatin methacryloyl (GelMA) hydrogels. Derived from gelatin, GelMA hydrogels are biomimetic, biocompatible, and bioactive. Functionalization of gelatin into GelMA renders GelMA stability under physiological temperatures as well as enhanced tunability of mechanical properties. We fabricated a library of GelMA hydrogels and composites that capture a range of biomechanical properties specifically designed to mimic tissue biomechanical properties. We then construct GelMA hydrogel composites by combining GelMA hydrogels with other materials, including electrospun fibers and hyaluronic acid methacrylate. We perform sophisticated material characterization with spherical nanoindentation and define the effects of biomechanical properties on cellular behavior and the effect of cells on hydrogel mechanical properties. We demonstrated that GelMA hydrogel platforms are adaptable for studying dynamic endometrial processes, including endometrial angiogenesis, hormone responsiveness (e.g., decidualization of endometrial stromal cells), epithelial monolayer formation in a stratified tissue model, and trophoblast invasion. We also established a three-dimensional model of the vaginal epithelium by incorporating primary human vaginal epithelial cells in gelatin-elastin fiber composites impregnated with GelMA hydrogels. Our ongoing studies seek to advance these existing model systems into complex, three-dimensional tissue mimics of the endometrium and vagina for not only basic science purposes but also for regenerative medicine applications.

ABOUT the SPEAKER

Dr. Samantha Zambuto is currently a T32 postdoctoral fellow in the Clinical Outcomes Research Training Program in Female Lower Urinary Tract Disorders at Washington University in St. Louis. She is dual affiliated with both biomedical engineering and obstetrics and gynecology and is co-advised by Dr. Michelle Oyen, PhD and Dr. Jerry Lowder, MD. Prior to coming to Washington University in St. Louis, she received her PhD from University of Illinois Urbana-Champaign under the guidance of Dr. Brendan Harley (Dissertation: 'Biomaterial-based Models of the Endometrium and Trophoblast Invasion to Investigate Early Pregnancy'). She received her bachelor's degree in biological engineering from Cornell University, her master's degree in biomedical engineering from Brown University, and is currently enrolled in a Master of Population Health Sciences at Washington University School of Medicine. She is deeply committed to improving health equity in science and seeks to use engineering techniques to understand pregnancy, child birth, and the female reproductive system by creating sophisticated tissue engineered models of the endometrium and vagina.

Monday, March 18 at Noon
1003 Engineering Centers (Tong Auditorium)