

Project Summary

Proposed Vision. Systems for improving women's health lag dramatically behind other areas of healthcare. A lack of knowledge regarding female-specific physiology and the dramatic structural changes exhibited by tissues during events such as pregnancy and childbirth are major contributors to this deficiency. The concept driving the Engineering Research Center for Integrated Mechanobiology for Women's Health (IMWEL) is that understanding the extreme material and mechanical properties exhibited by biological tissues will make possible a new generation of technologies for detecting, predicting, and ultimately improving health. IMWEL brings together a strategic team of mechanical engineers, biomedical engineers, chemical engineers, data scientists, physical scientists, clinicians, and psychologists across four institutions to develop a constellation of technologies that restore the biomechanical form and function of biological tissues. These technologies will directly incorporate the emerging field of mechanobiology into platforms for imaging and simulating physiological systems, for the first time applying such considerations across four physiological systems central to women's health. Supporting these research activities is a successful innovation ecosystem, which will be expanded to address current barriers that face commercialization of products in this space. In addition, IMWEL's workforce development program will train new researchers at the intersection of mechanobiology and women's health, promoting a diversity and culture of inclusion that is particularly strategic for this emerging area of engineering. Through these activities, IMWEL's 10-year vision is to integrate mechanical forces into the lexicon of diseases disproportionately affecting women, delivering engineering systems to support healthy reproduction, childbirth, and aging.

Intellectual Merit. The impressive material properties and mechanical capabilities exhibited by biological tissues feature prominently in reproduction. Over the course of pregnancy and childbirth, tissues must first stretch to accommodate yet contain the growing fetus over the course of weeks and months, then abruptly contract and rupture to allow safe delivery. Equally striking is the ability of tissues to recover quickly after this event. However, this healing process is often incomplete, leading to long-term effects on the mother's health. Towards a clearer understanding of the mechanical state of tissues over the course of this process, as well as the biological processes that are central to these changes, IMWEL will develop technologies for profiling the structure, biological composition, and physical properties of tissues systems over an unprecedented range of spatial and temporal scales. This Center will also develop convergent knowledge of mechanobiology at molecular, cellular, and tissue scales, investigated using -omic technologies. Big Data and Bioinformatics technology thrusts, combined with Multiscale Biomechanical Computation and MechanoOrgan technologies, will lead to a new, multi-faceted, systems-level understanding of physiologies specific to women's health.

Broader Impacts. IMWEL represents an innovative and compellingly strategic intersection of two research areas. As a new approach, the technologies and knowledge that will be generated by IMWEL face several challenges in commercialization. Technology innovation programs across all of IMWEL's institutes and the vibrant New York City, Pittsburgh, and Irvine ecosystems will be cooperatively engaged to advance understanding of and investment in solutions in women's health, building a pipeline for deployment of this and future innovations. In addition, IMWEL programs will advance the career goals of researchers, particularly women and underrepresented minorities who are strategically poised to be the next leaders of this emerging field. The IMWEL team includes two minority-focused institutions, and will leverage training programs across the Center to develop a diverse and inclusive workforce, supporting both short- and long-term routes of entry into careers in this area. Long-term and wide societal impact of IMWEL will also be ensured through programs that transform education with concepts of mechanobiology and women's health, and also trains IMWEL participants in communicating research and results with a wide range of communities.

In summary, the research, workforce development, diversity, and innovation ecosystem interconnected components proposed in this ERC will bridge the gap between the mechanobiology engineering community and practitioners in women's healthcare through convergent integration of engineering, biology, and biomedicine.