



Director's Overview

X. Edward Guo, Lead PI, Center Director, Columbia University (CU)
Kristin Myers and Lance Kam, Center Deputy Directors, Co-PIs (CU)
Michelle Oyen, Co-PI, Washington University in St. Louis (WUSTL)
Steven Abramowitch, Co-PI, University of Pittsburgh (Pitt)
Wendy Liu, Director of Integration, University of California at Irvine (UCI)



IMWEL



Engineering Research Center
for Integrated Mechanobiology for
Women's Health



The **vision** of our center is to provide *effective and equitable* tools to *improve women's health* by applying *mechanics-based physiology*.

The **mission** of our center is to:

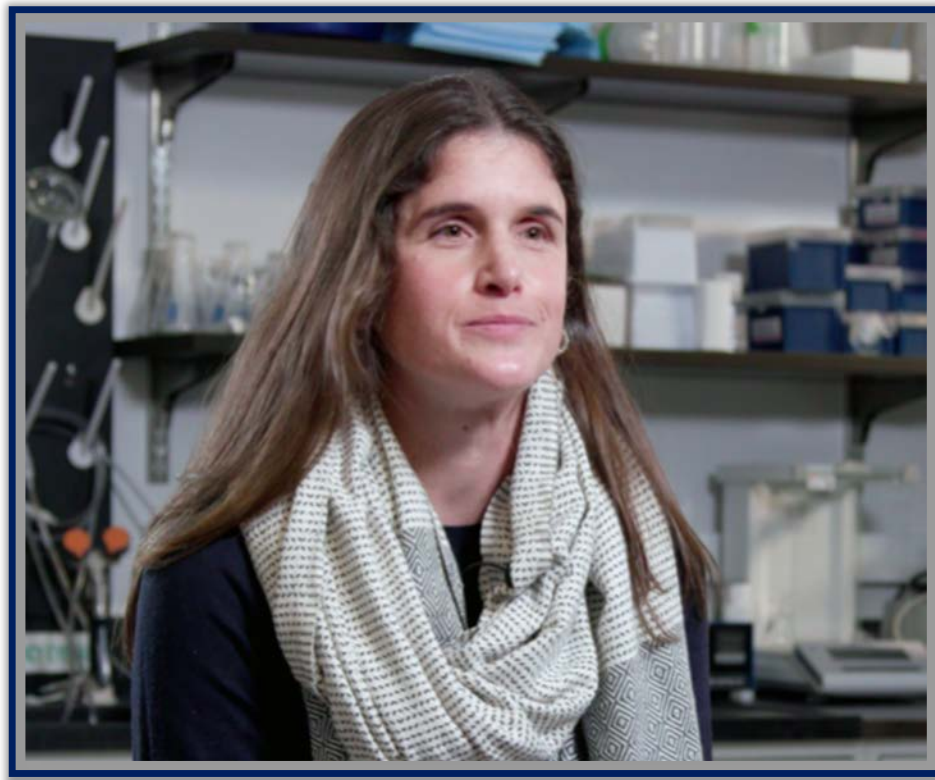
- Bridge the current gaps between computational tools and *ex-vivo* systems
- Focus on women-centric physiology
- Build a system of devices and models
- Train engineers at the interface of mechanobiology and women's health

Brittney's story...



Preterm birth

“When I gave birth and lost my daughter, Iris, it was about two days afterwards when I was still lying in the hospital bed, and we asked the Ob/Gyn - **Why?**



Brittney Crystal
Founder Iris Fund
IMWEL community partner

Aren't there **better interventions** for high-risk mothers?”

The reply was there were **none.**

There was a collective **gasp in the room.**

Brittney is not alone

**PRETERM
BIRTH RATE**
10.2%



- Preterm birth is the number one cause of neonatal death.
- Premature babies are at significant risk of death or lifelong disabilities.
- Preterm birth is associated with maternal mortality
- **Cost of poor American maternal healthcare > \$30 billion per year**


(Maternal health care facts, Vice President Harris, January 23, 2022)



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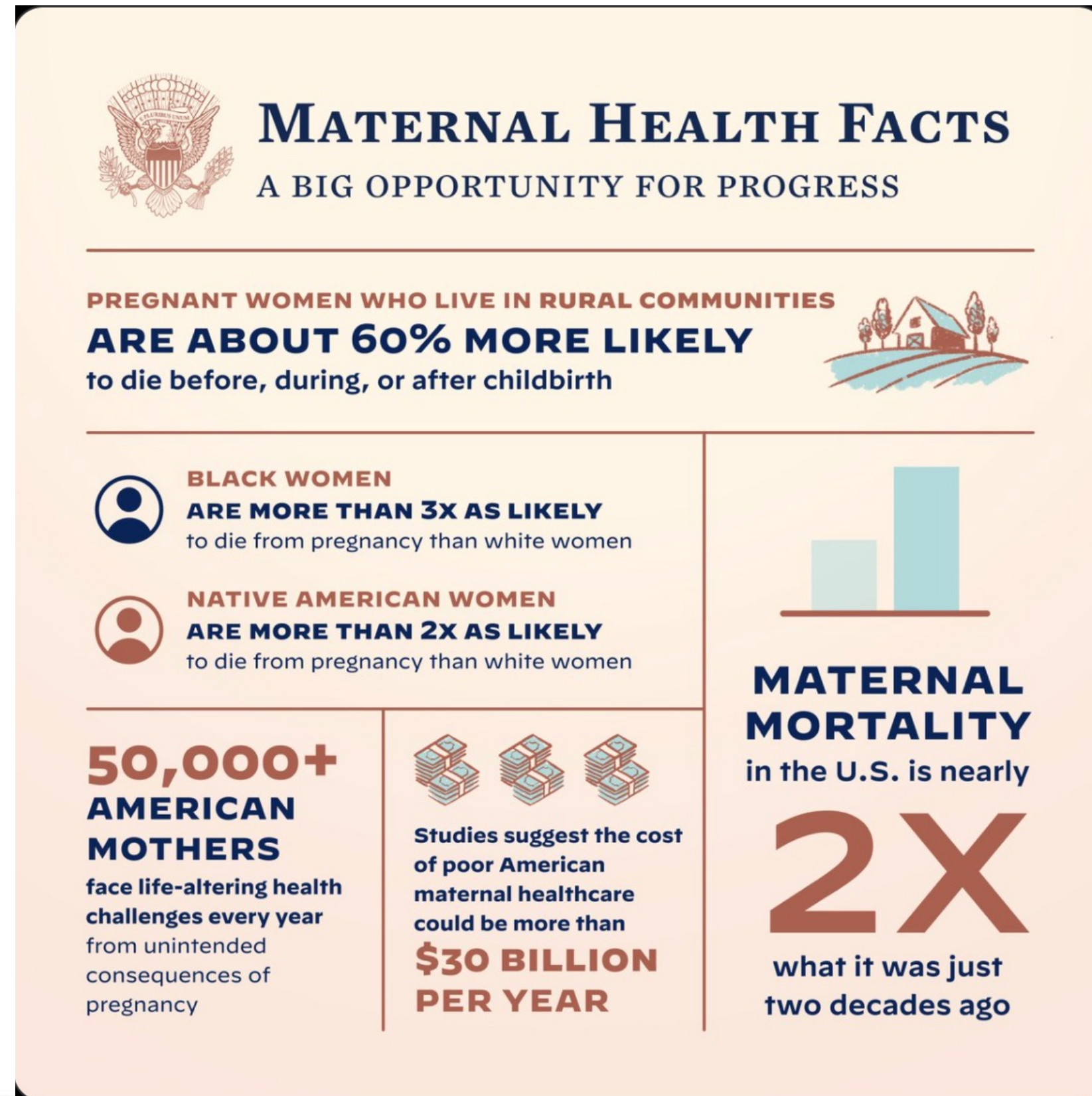
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Maternal mortality and morbidity is a serious crisis in our country.

 **Vice President Kamala Harris** ✓
@VP
United States government official


Maternal mortality and morbidity is a serious crisis in our country. Women are dying at a higher rate than any other developed nation in the world. Today on Maternal Health Awareness Day we must continue to do everything we can to protect and strengthen maternal health.


VP Harris, Twitter, January 23, 2022




MATERNAL HEALTH FACTS


A BIG OPPORTUNITY FOR PROGRESS

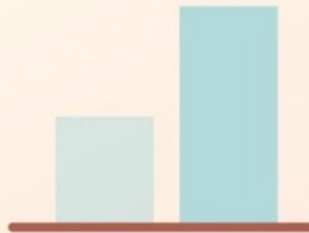
PREGNANT WOMEN WHO LIVE IN RURAL COMMUNITIES ARE ABOUT 60% MORE LIKELY to die before, during, or after childbirth 

BLACK WOMEN ARE MORE THAN 3X AS LIKELY to die from pregnancy than white women 

NATIVE AMERICAN WOMEN ARE MORE THAN 2X AS LIKELY to die from pregnancy than white women 

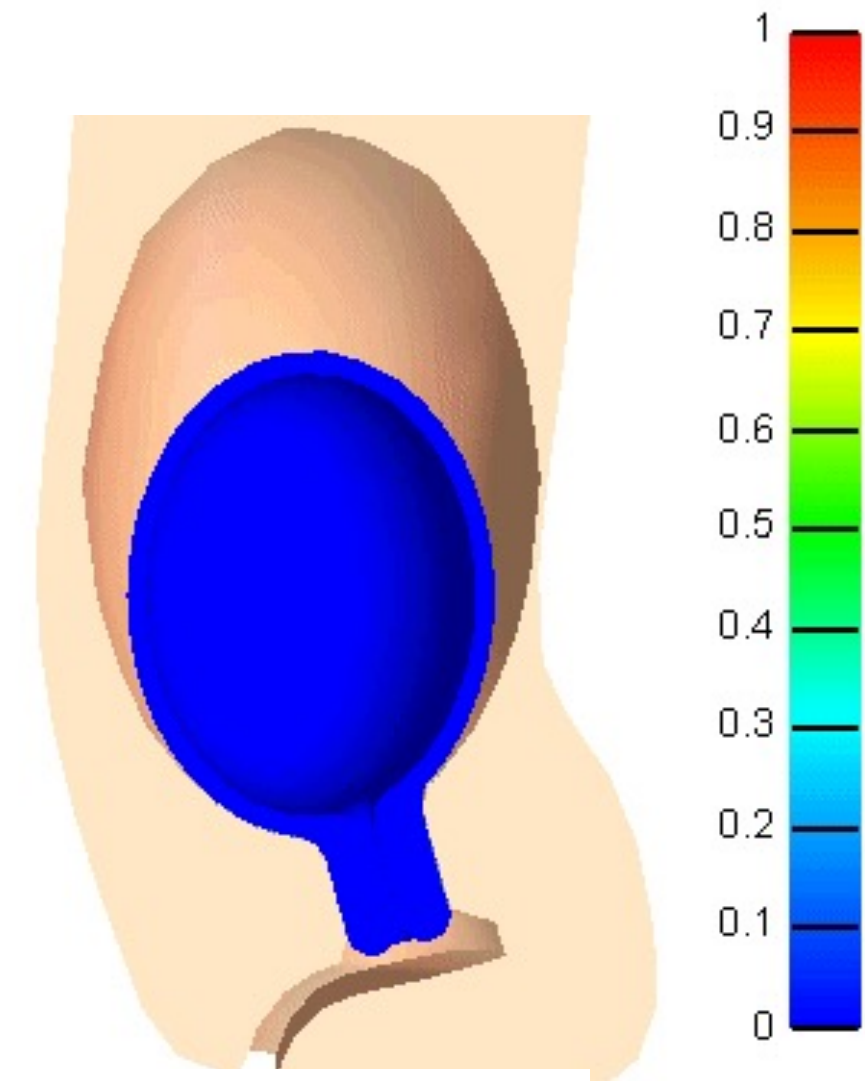
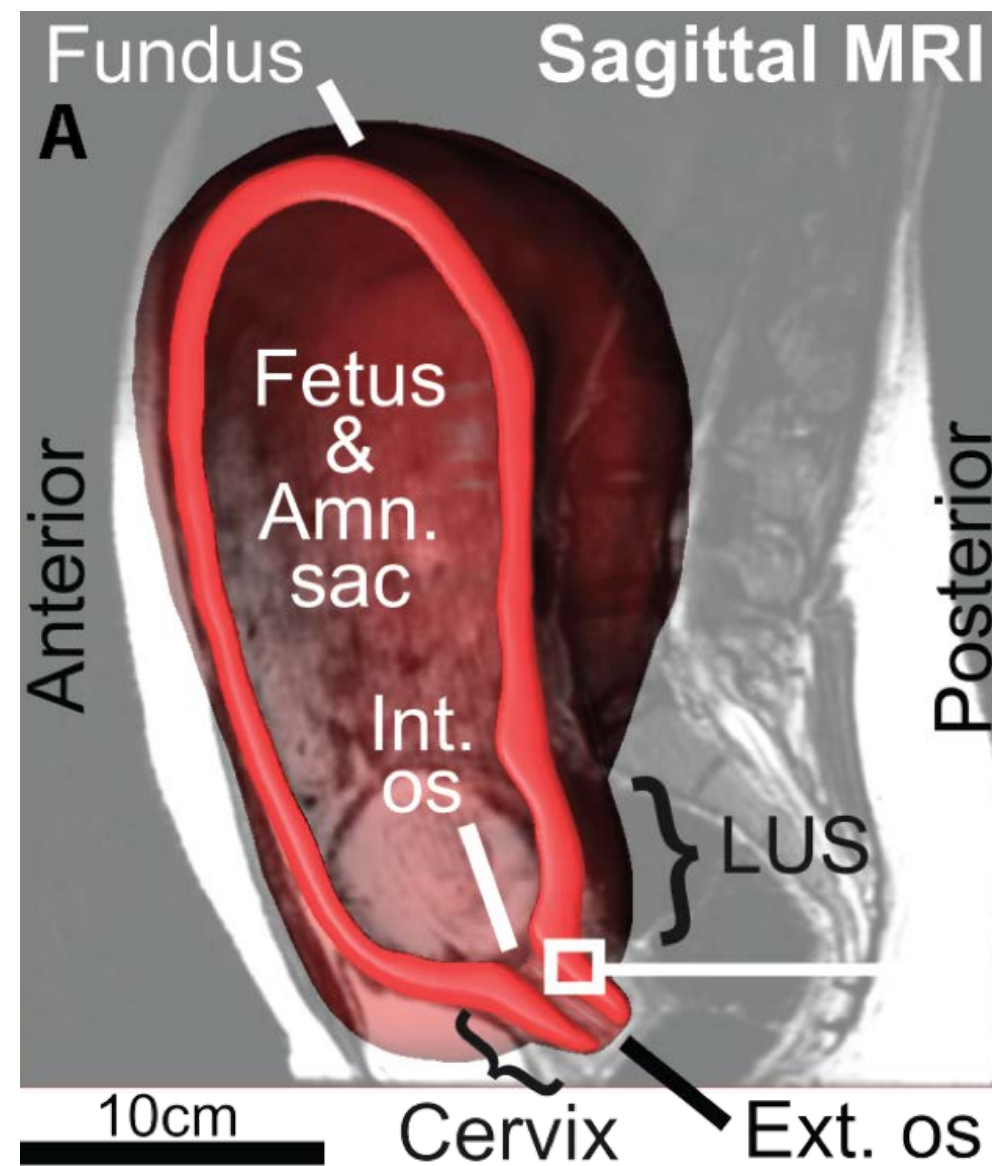
50,000+ AMERICAN MOTHERS face life-altering health challenges every year from unintended consequences of pregnancy

Studies suggest the cost of poor American maternal healthcare could be more than **\$30 BILLION PER YEAR** 

MATERNAL MORTALITY in the U.S. is nearly **2X** what it was just two decades ago 

A mechanics-based understanding could transform women's health

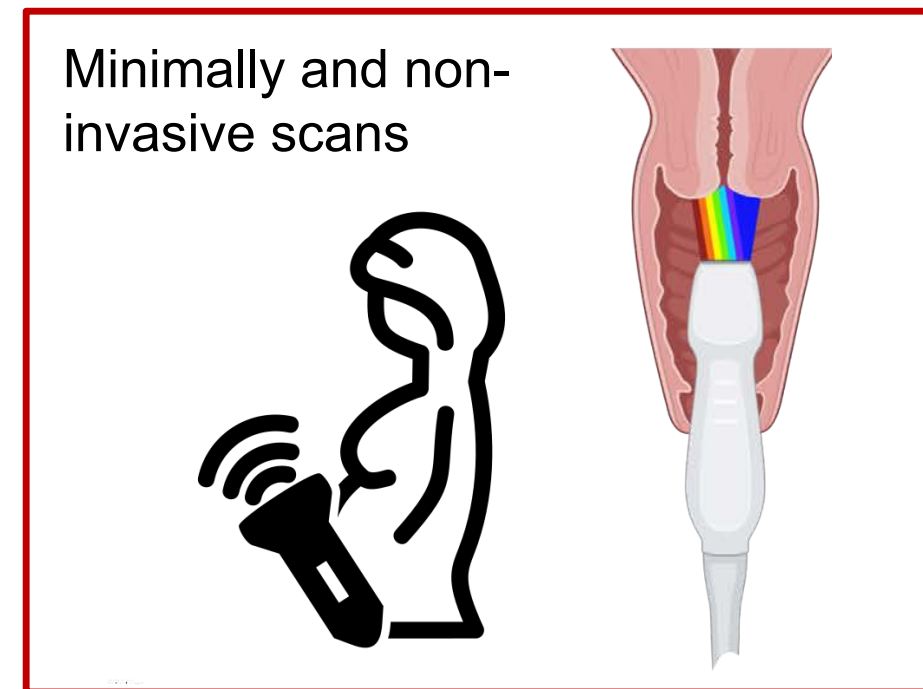
- The fetus is supported and protected by biologically-active soft tissue structures.
- The **cervix, uterus, placenta, and fetal membranes** have remarkable mechanical functions.
- Biomechanical signals trigger tissue **remodeling, contractility, and rupture.**
- The mechanical integrity of these tissues are critical for a successful pregnancy.



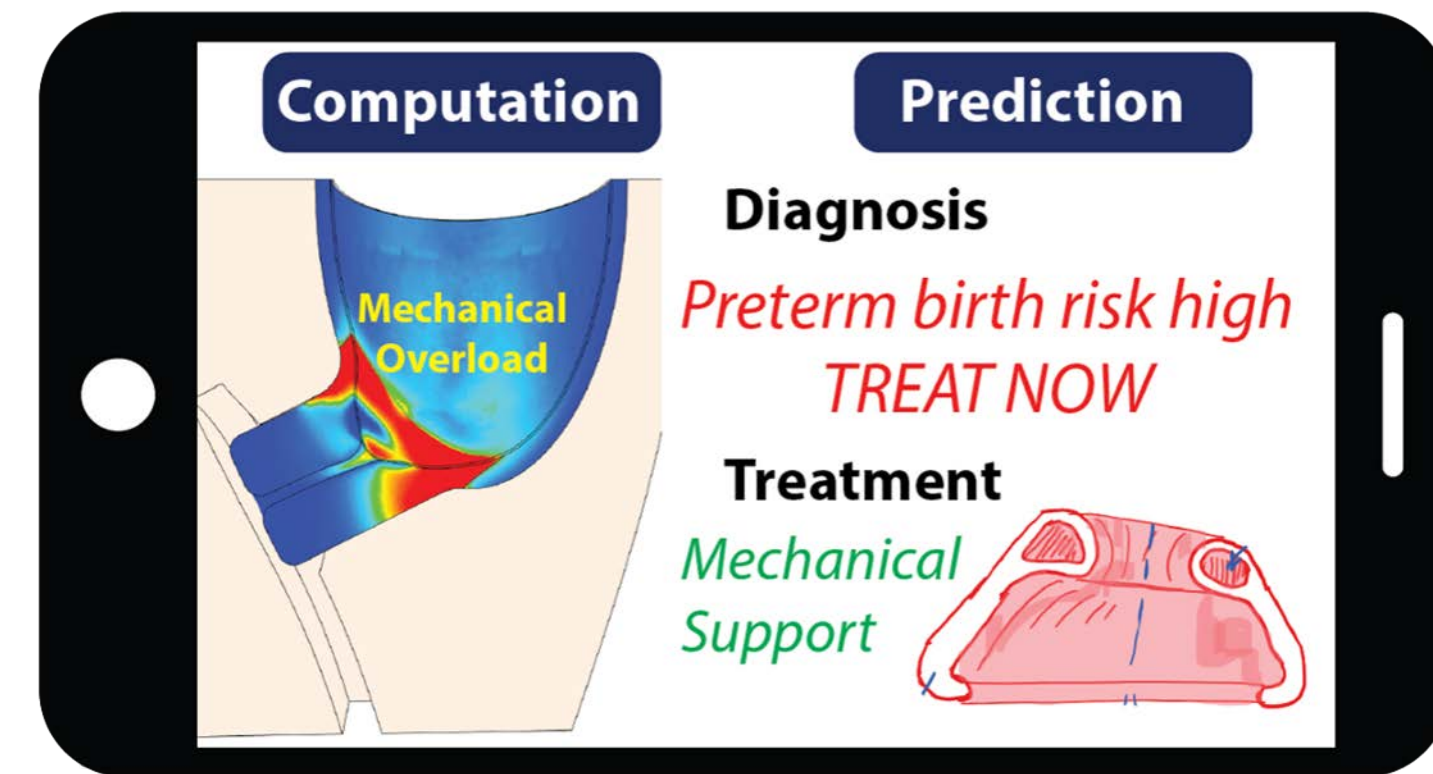
Uterine weight ↑ 15X
Volume capacity ↑ 500X

A preterm birth risk assessment tool to alert action can be built with a mechanics-based approach

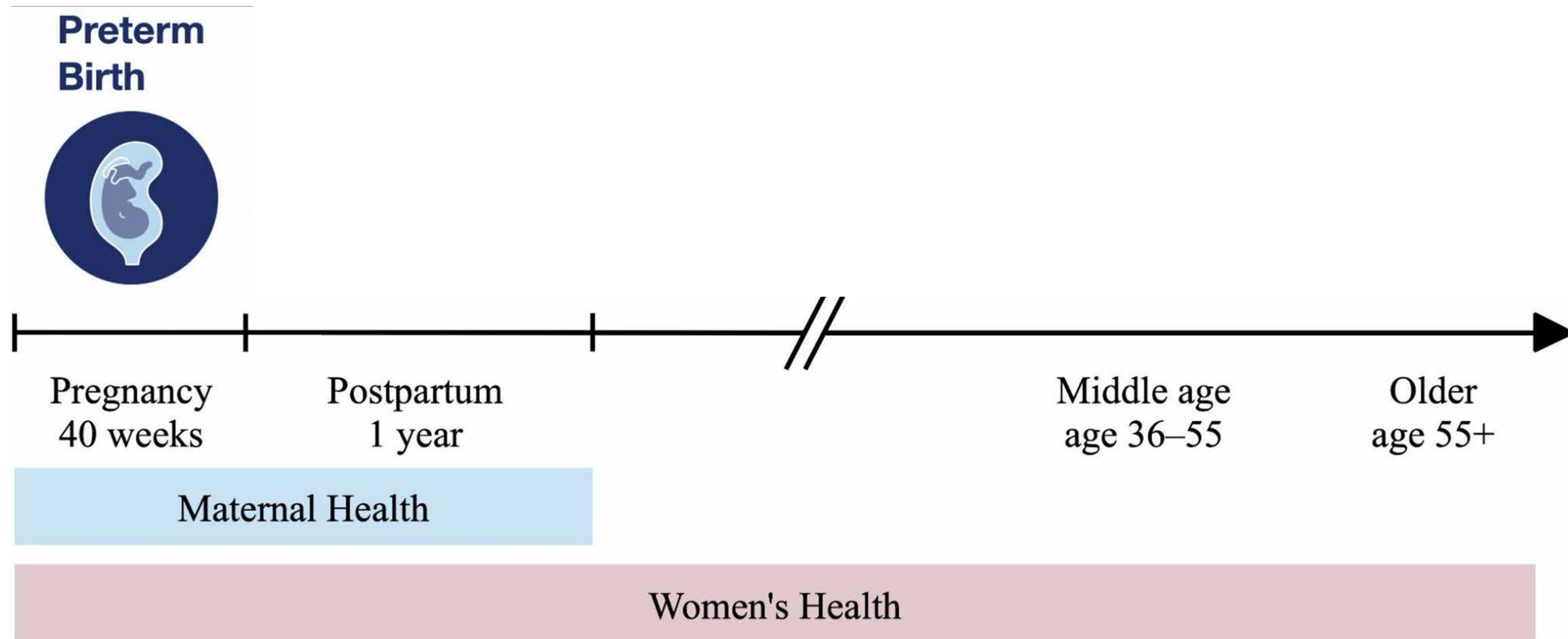
- Given:**
patient-specific metrics
- Evaluate:**
tissue loading and remodeling
- Identify:**
clinical biomarkers
- Investigate:**
personalized clinical solutions
- Improve:**
maternal and fetal health



Patient + Caregiver Partnership



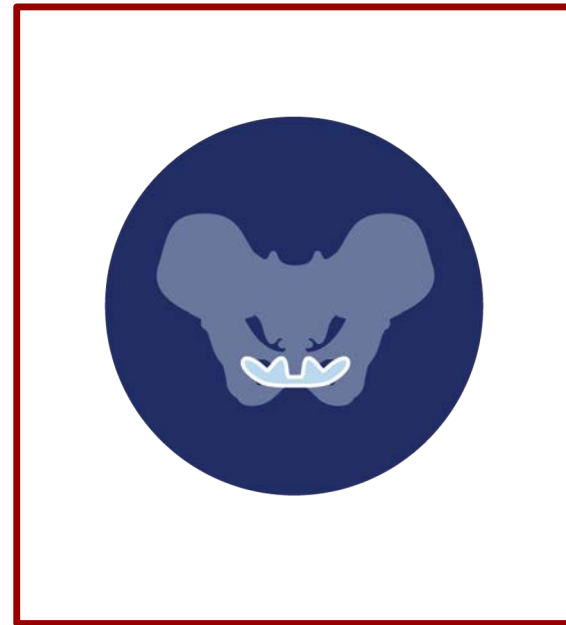
The physiologic events in this time period are dramatic, with immense growth, remodeling, and repair



Jane's story...



Preterm birth



Pelvic floor disorders

In the privacy of a doctor's office...

a young mother of 3 young kids breaks down.

She can't respond to "Mommy up" without...

"falling out"

"leaking all over herself."

She pushes her kids away when they crawl on her lap.

She has lost intimacy with her husband.

She feels like a failure as a mother and a wife.

Jane is not alone

Pelvic floor disorders have a profoundly negative impact on an affected woman's sexuality, body image, and sense of well being.

Pelvic Floor Disorders are common:

24% of women

have at least one pelvic floor disorder in their lifetime

13% of women

will choose to have their pelvic floor disorder repaired surgically by the age of 80

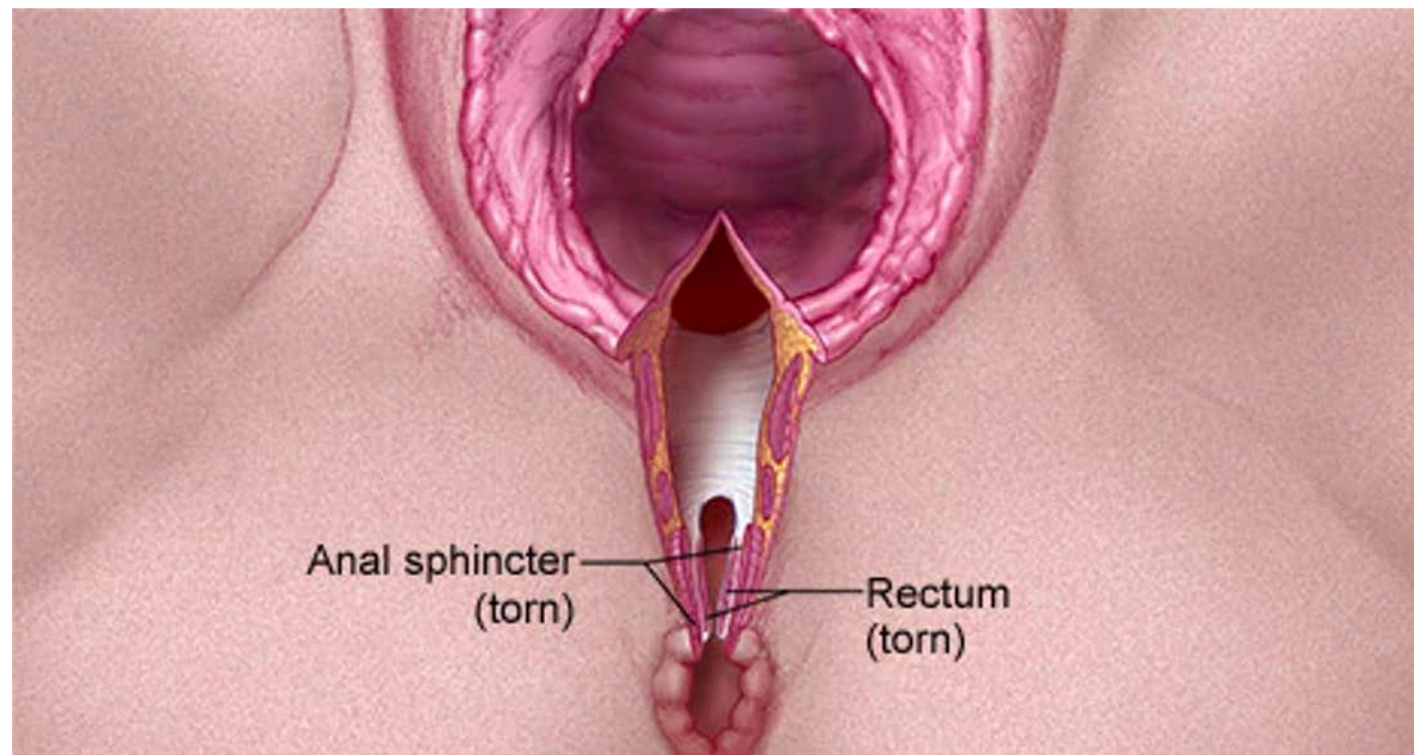
Huge economic burden:

> \$10 billion per year in US

A mechanics-based understanding could transform women's health

Today, no diagnostic tools or therapies exist to prevent pelvic floor injury.

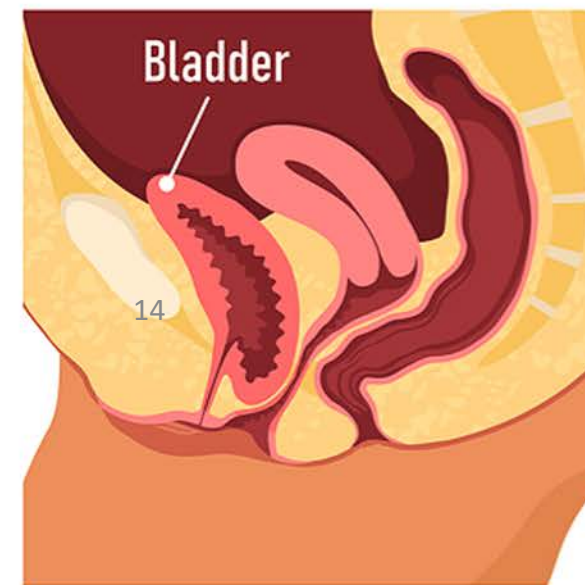
4th degree vaginal *tear*:



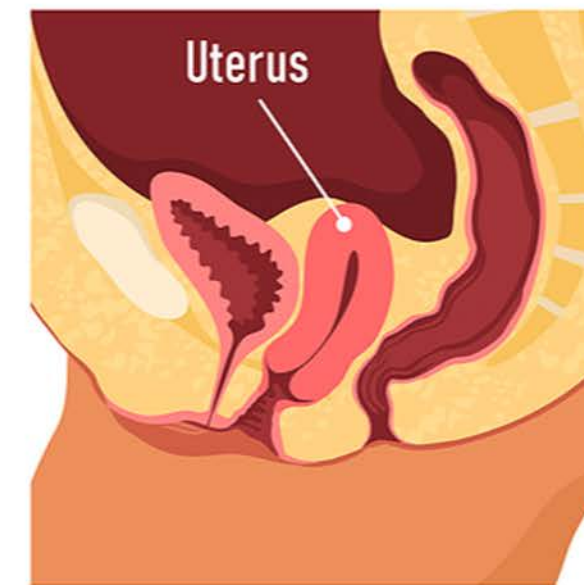
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Pelvic floor *prolapse*:

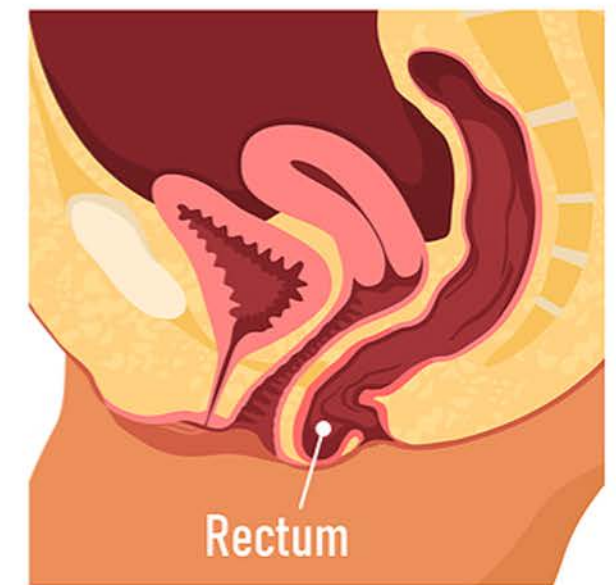
Cystocele



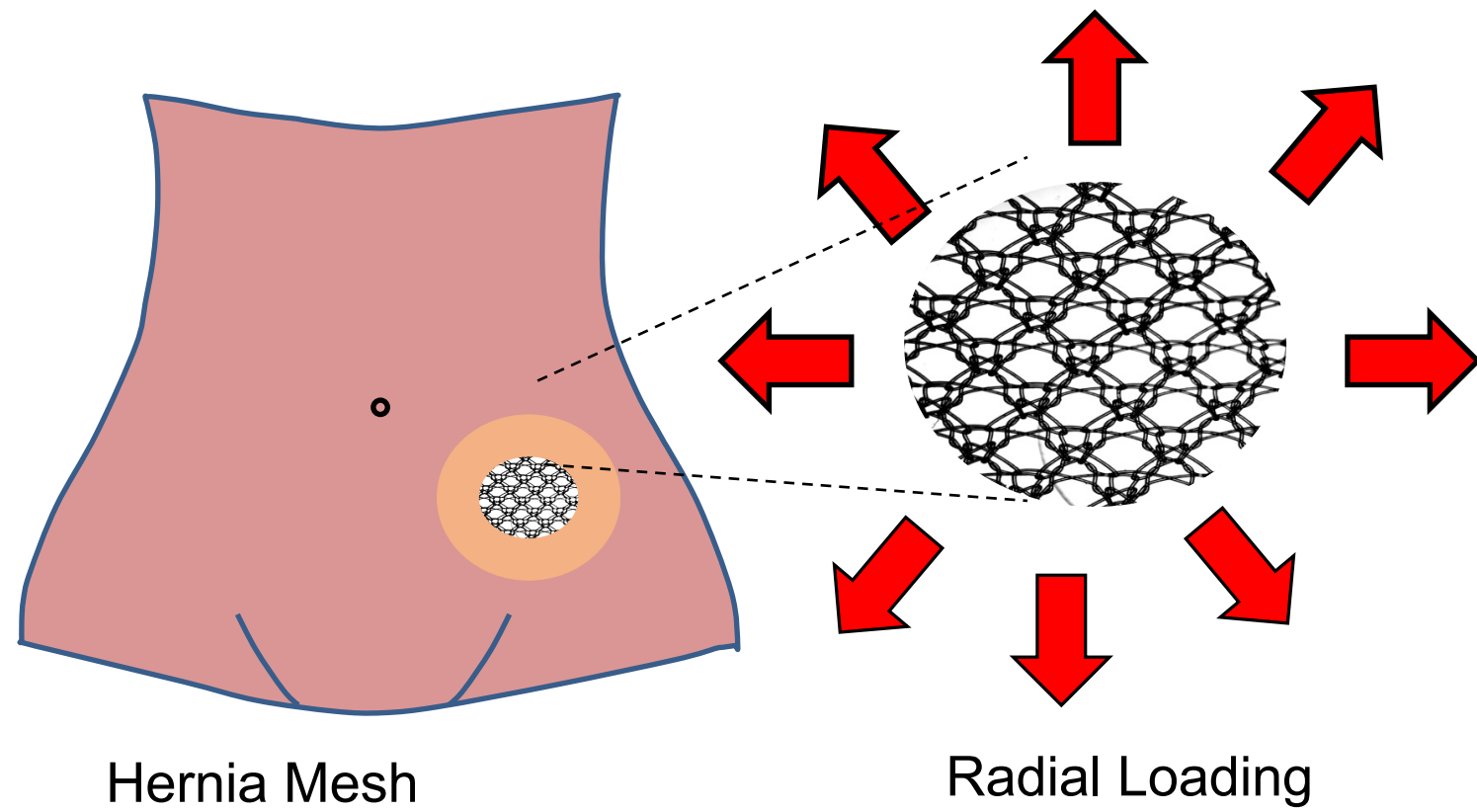
Uterine Prolapse



Rectocele



A mechanics understanding explains pelvic mesh failure

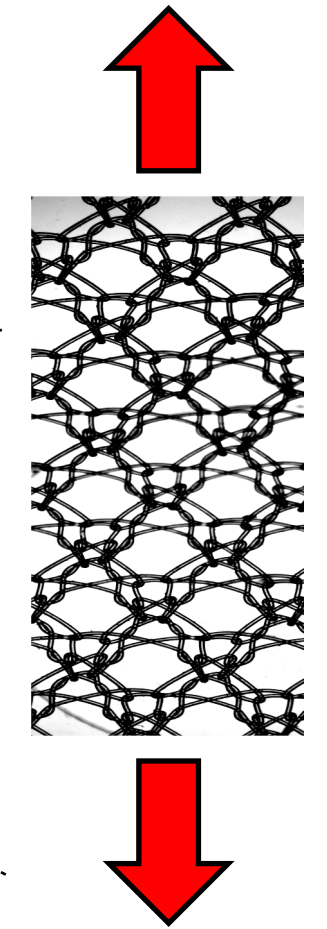


Applied to Prolapse Repair

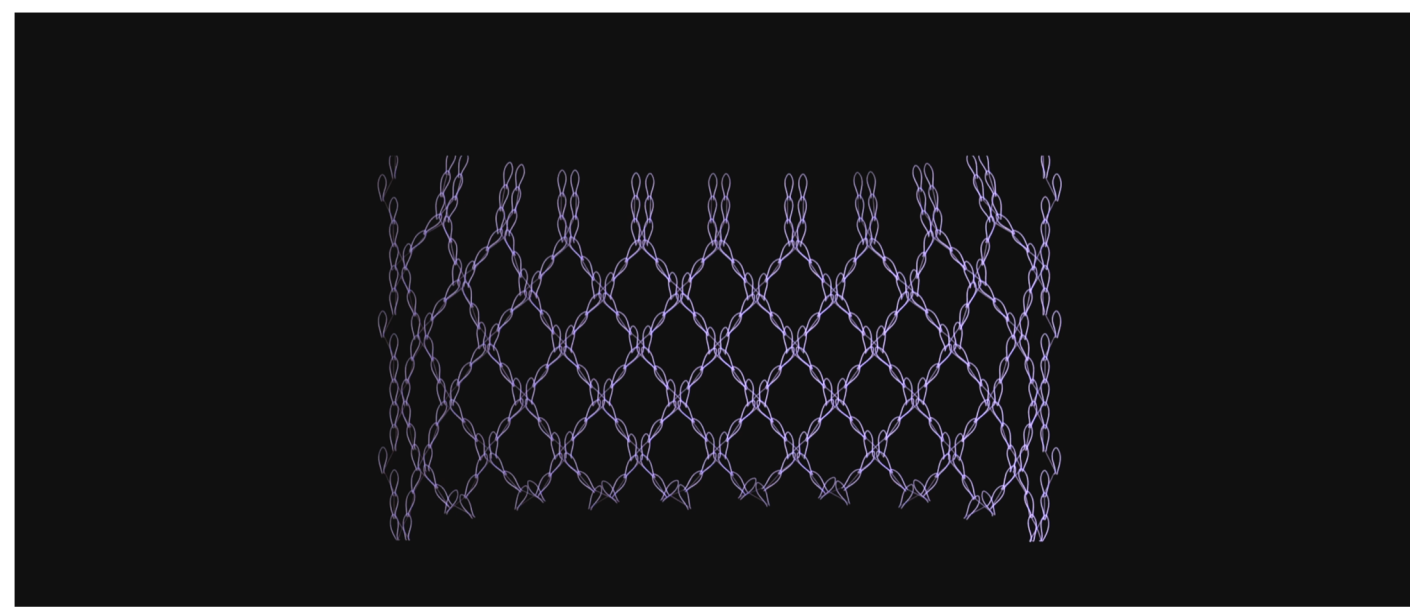
Prolapse Mesh



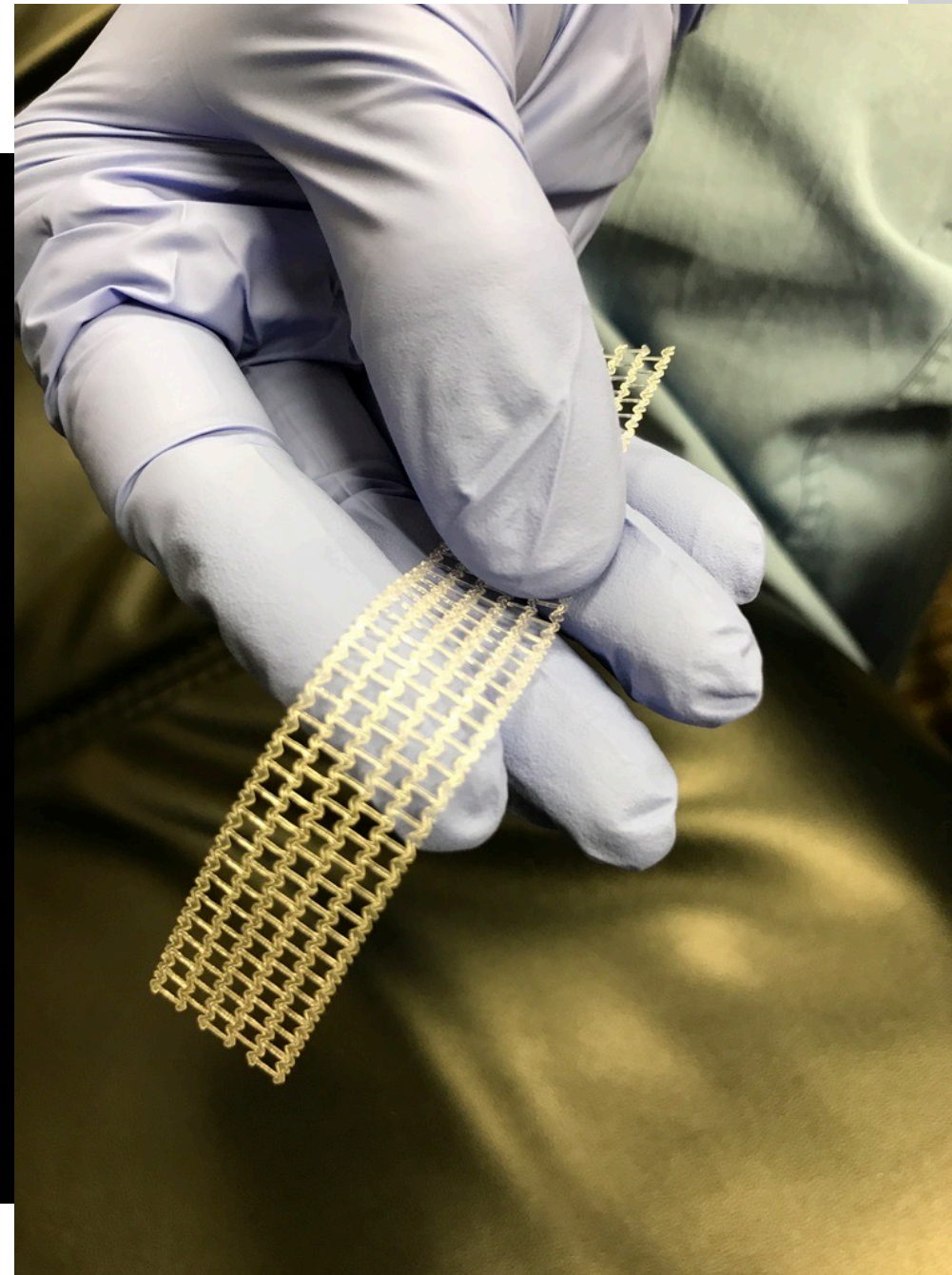
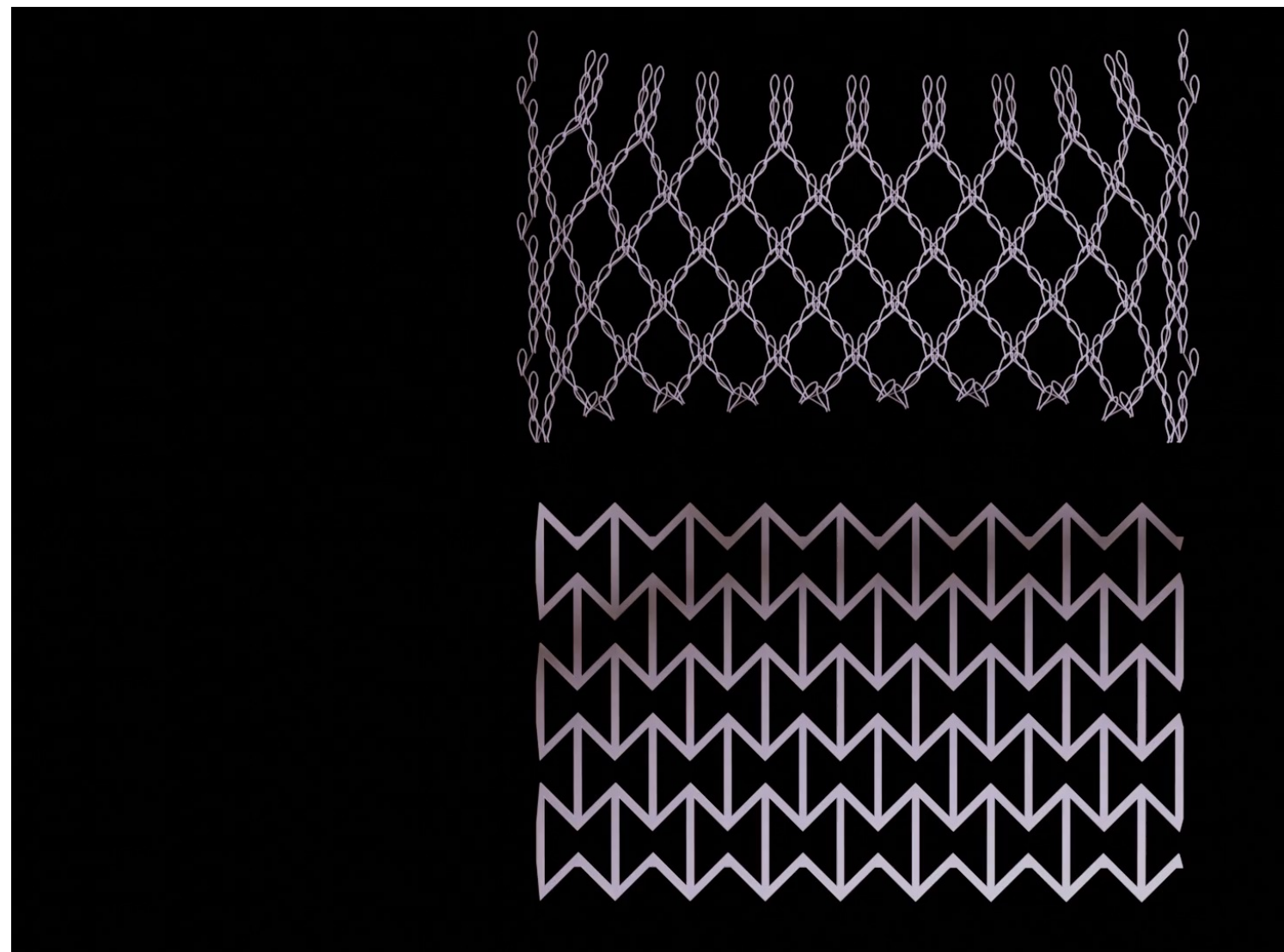
But...



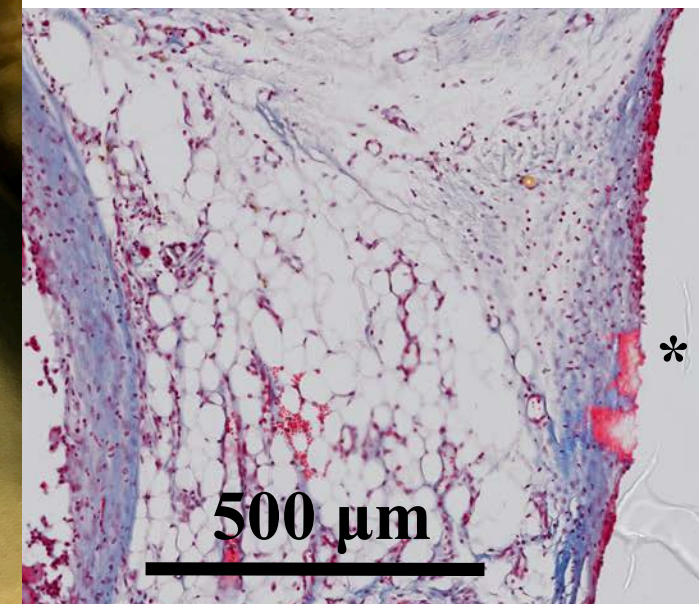
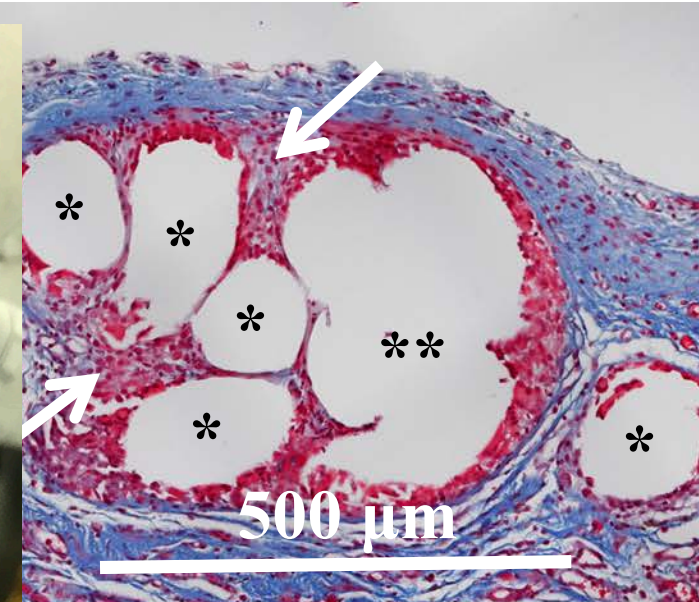
Leads to Complications



Improved host response can be built with a mechanics-based approach



PROTOTYPE DEVICE



*indicates implanted material



Katrina Knight, Pitt

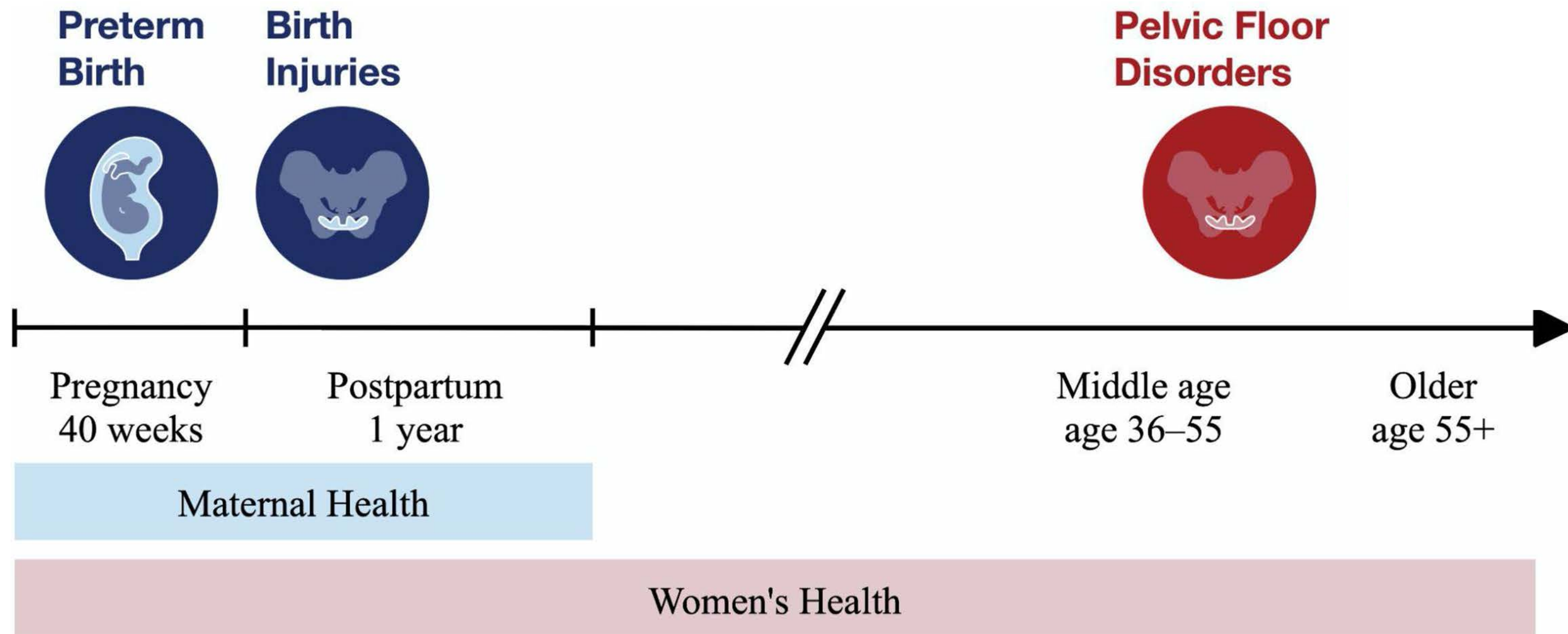


Steven Abramowitch, Pitt



Pamela Moalli, Pitt

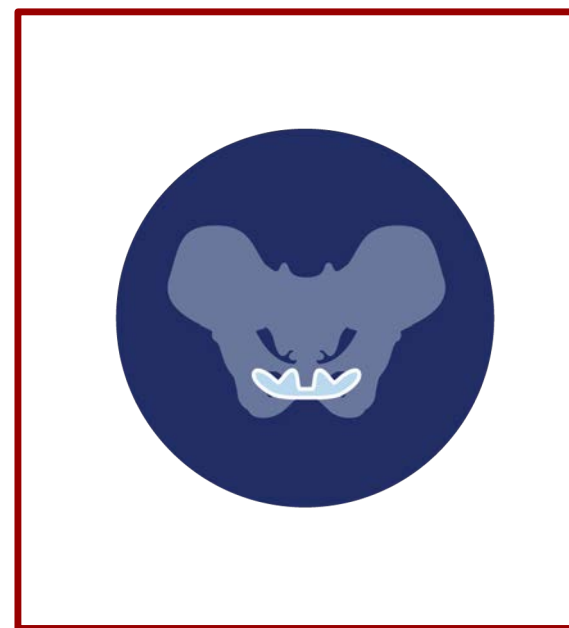
Pelvic floor disorders span a large age range from middle age to later in life



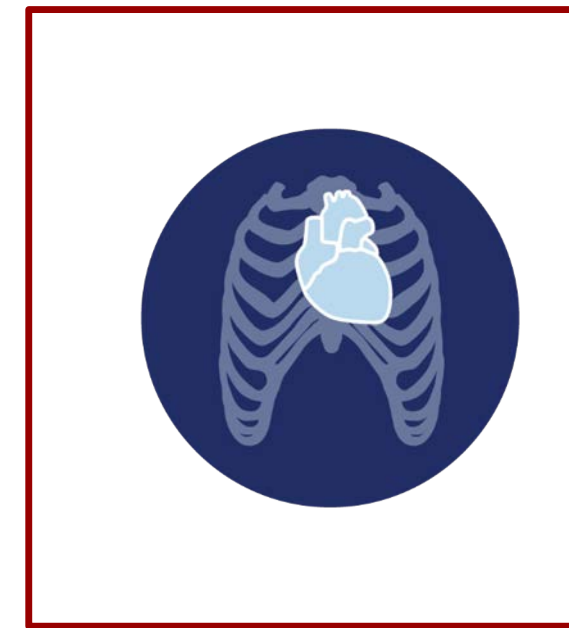
A woman's story we know...



Preterm birth



Pelvic floor disorders



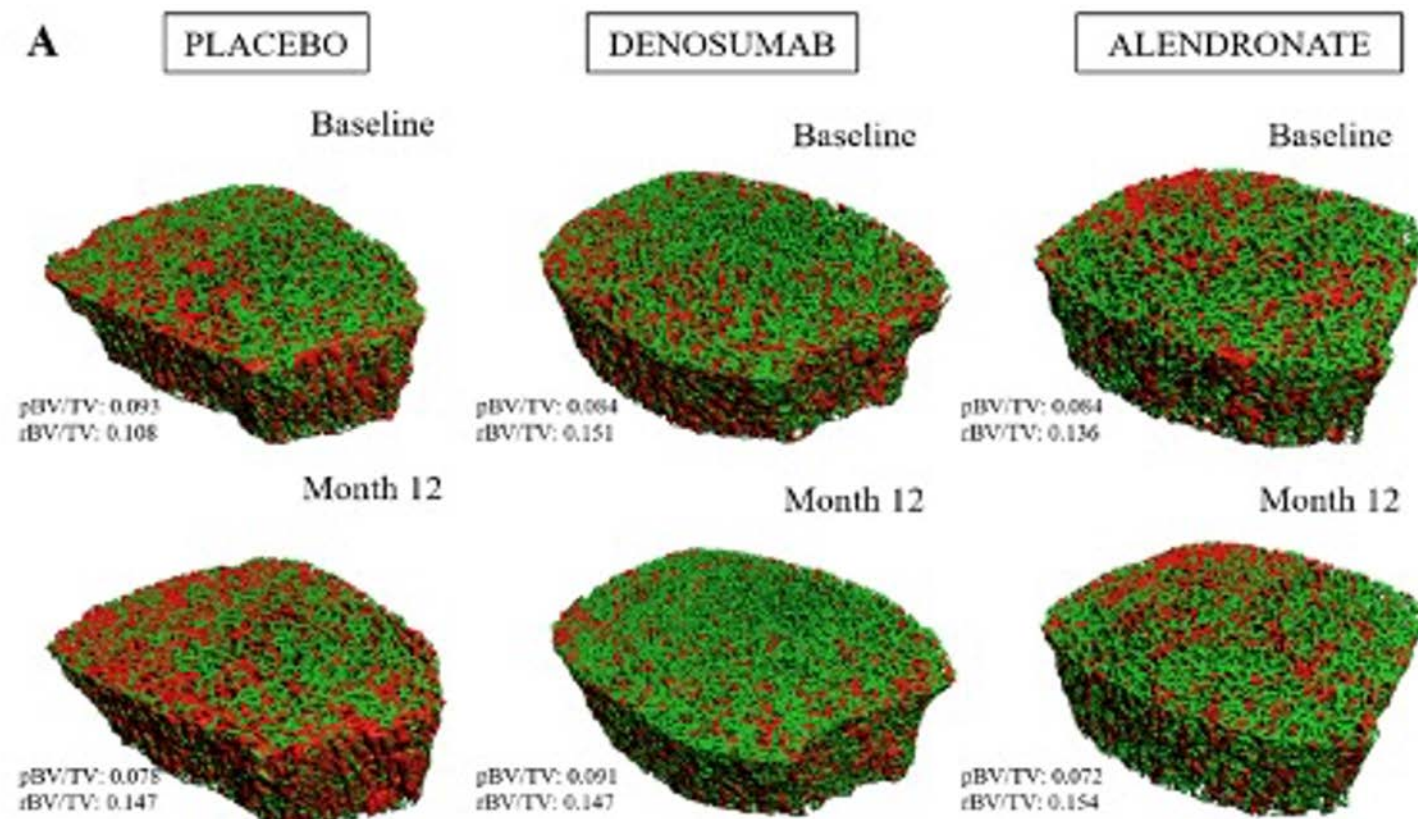
Healthy aging

Mechanics-based interventions work

Women suffering from osteoporosis have benefited from engineering research, a strong engineering workforce, and industry partnerships. This combination works!

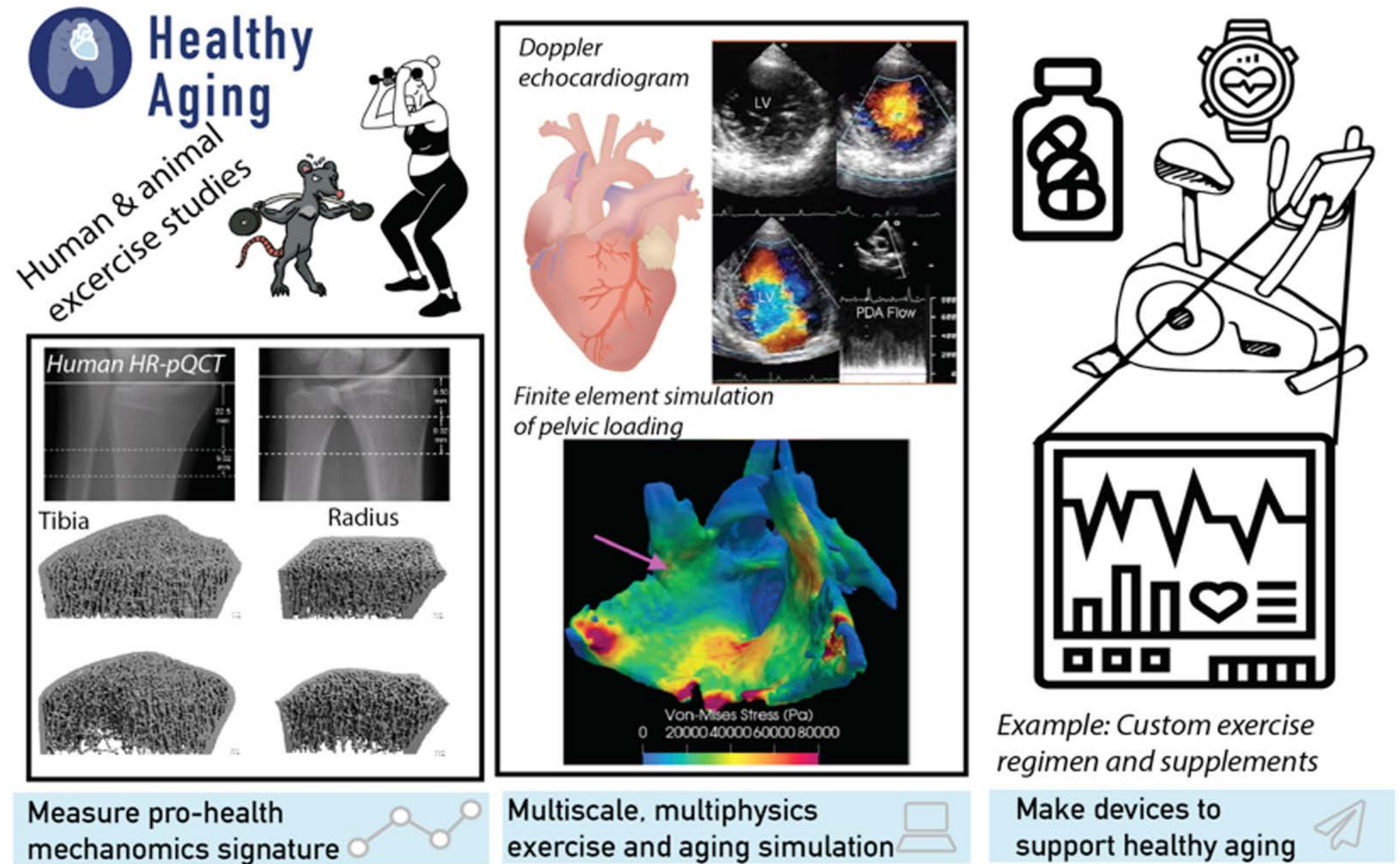
Drugs targeting bone **density**, **microstructure**, and **fragility**

Wearable devices to detect fall
(Apple Watch)

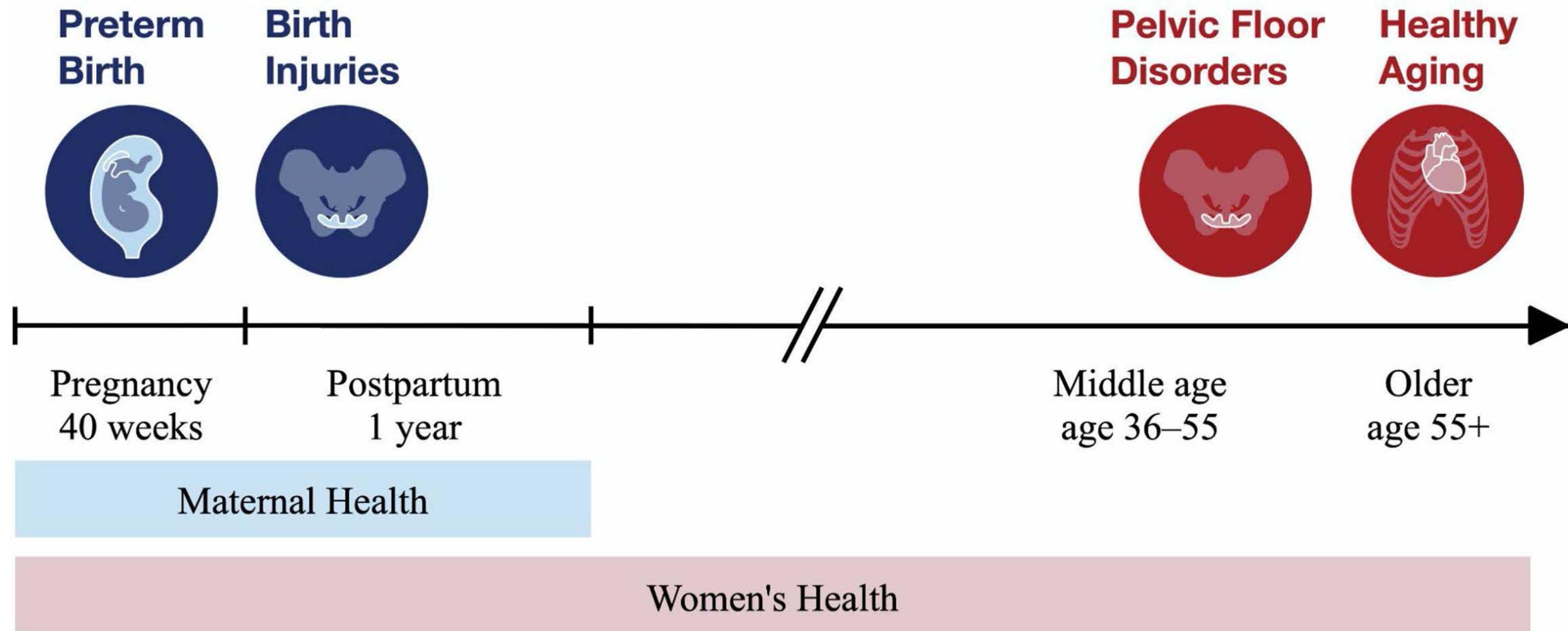


A mechanics-based understanding could transform women's health.

- Physical Exercise to Maintain and Improve Women's Health
- Particular Focus on Cardiovascular (CV) and Musculoskeletal (MSK) Systems
- Particular Focus on Black Maternal Health

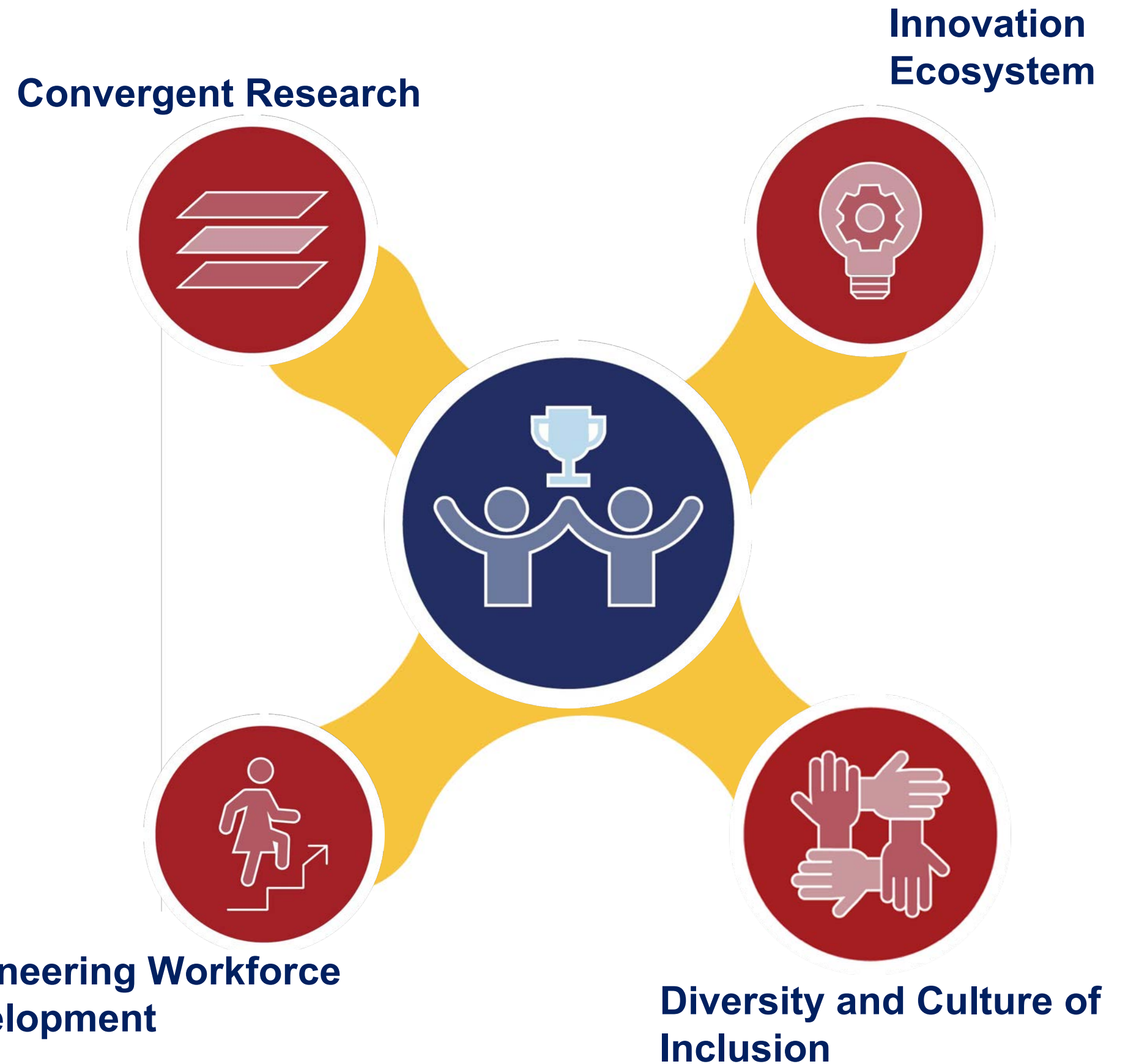


These stories provide strategic focus in three areas of women's health



The IMWEL Mission

- Bridge the current gaps between computational tools and *ex-vivo* systems
- Focus on women-centric physiology
- Build a system of devices and models
- Train engineers at the interface of mechanobiology and women's health



IMWEL has proven track records in institutional excellence in women's health and engineering



IMWEL is stronger with a team approach

Experts in biomechanics, mechanobiology, electrical engineering, entrepreneurship, medicine, social psychology, and women's health



IMWEL is stronger with a team approach

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Biomechanics and Mechanobiology



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Experts in biomechanics, mechanobiology, electrical engineering, entrepreneurship, medicine, social psychology, and women's health



Physician Scientists

IMWEL is stronger with a team approach

Experts in biomechanics, mechanobiology, electrical engineering, entrepreneurship, medicine, social psychology, and women's health



Women's Health



Convergent Research



Convergent Research



Innovation Ecosystem



Engineering Workforce Development



Diversity and Culture of Inclusion



Mechanical forces sculpt everyday living

Gravity



Athletic Training
& Exercise

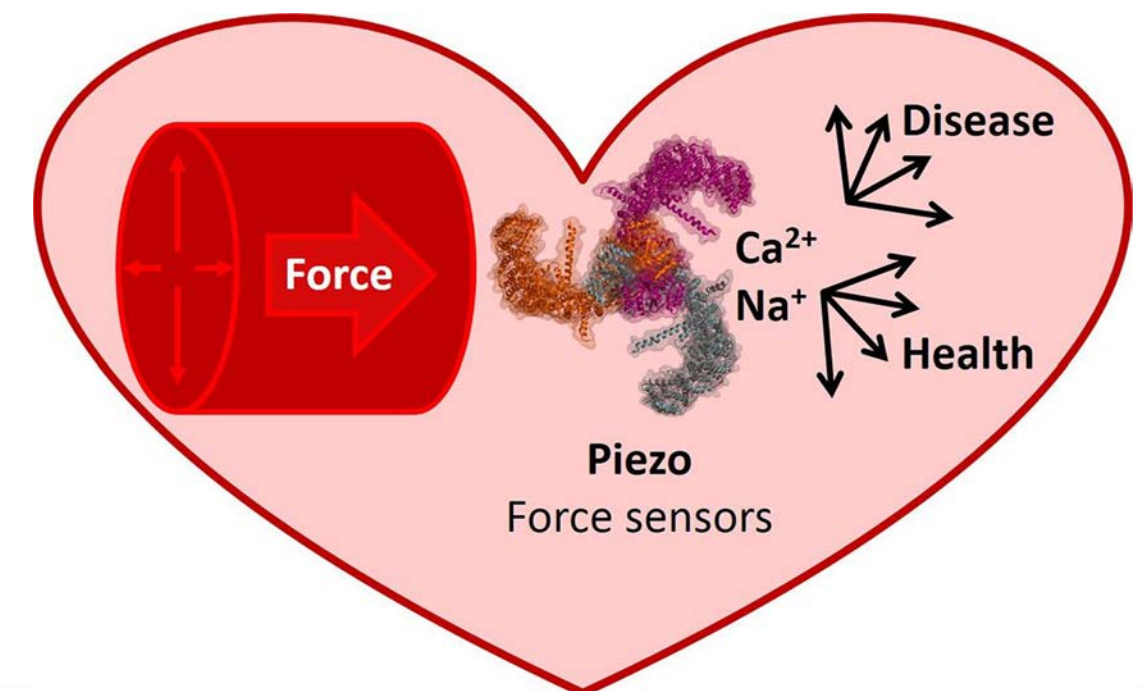


- Musculoskeletal support of the abdomen
- Cardiovascular pumping
- Bladder and rectum control and voiding
- Physical pain
 - Strong menstrual cramping, orthopedic disease and injury, sinus pressure, tension headache
- Surgical tools and biomedical devices
 - Sutures, forceps, aspirators, catheters, stents, prosthetics, implanted devices, etc.

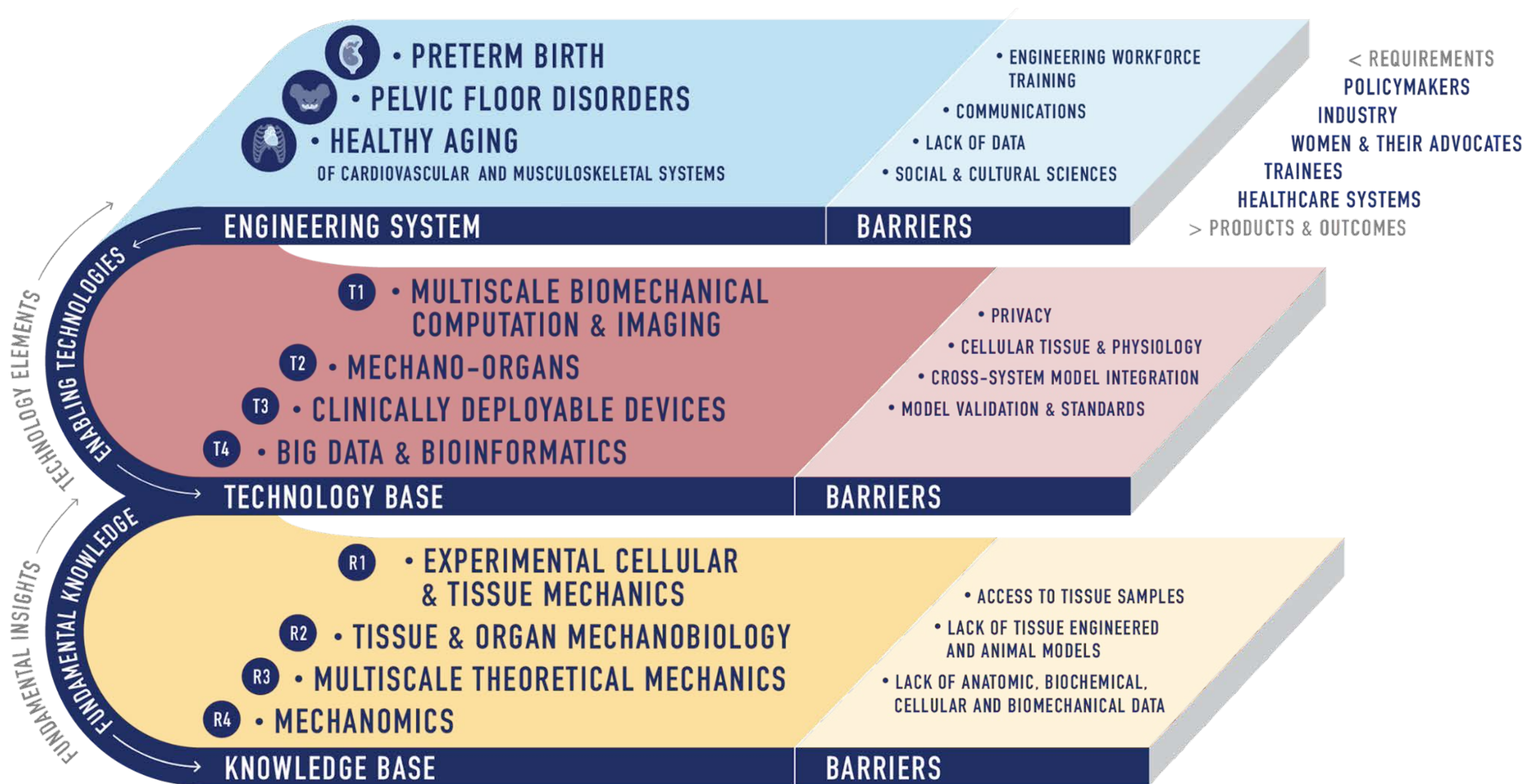
Mechanics based approaches = biomechanics + mechanobiology

Biomechanics explores how physical forces causes changes in biological systems and how they influence physiological/pathological functions.

Mechanobiology explores how physical forces influence specifically biological changes, such as cellular response.



Engineering System: A Constellation of Technologies to Maintain or Restore the Biomechanical Form and Function of our System Testbeds



Measure

Measure multiscale aspects of genetics and cell biology and tissue biomechanics

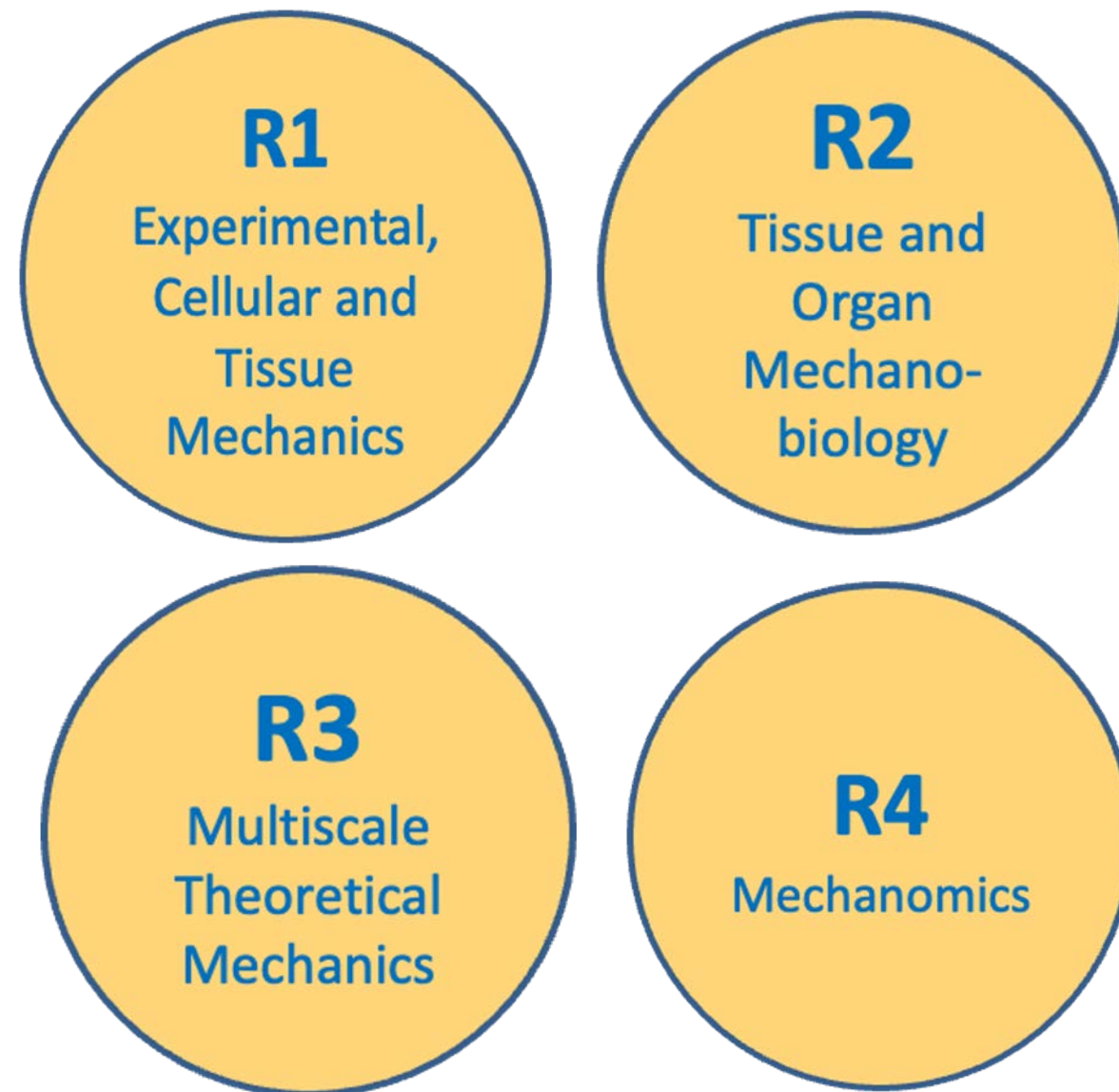
Model

Construct *in-silico* and *ex-vivo* models of both normal and pathological conditions

Make

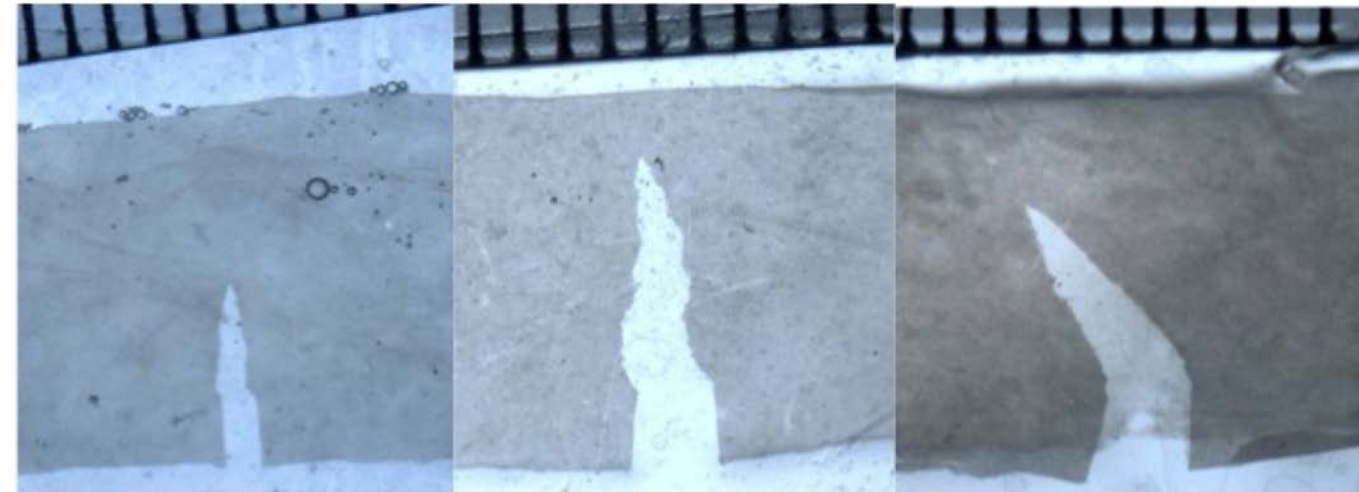
Make new devices to deploy for use in both research and clinical treatment

Research Thrusts



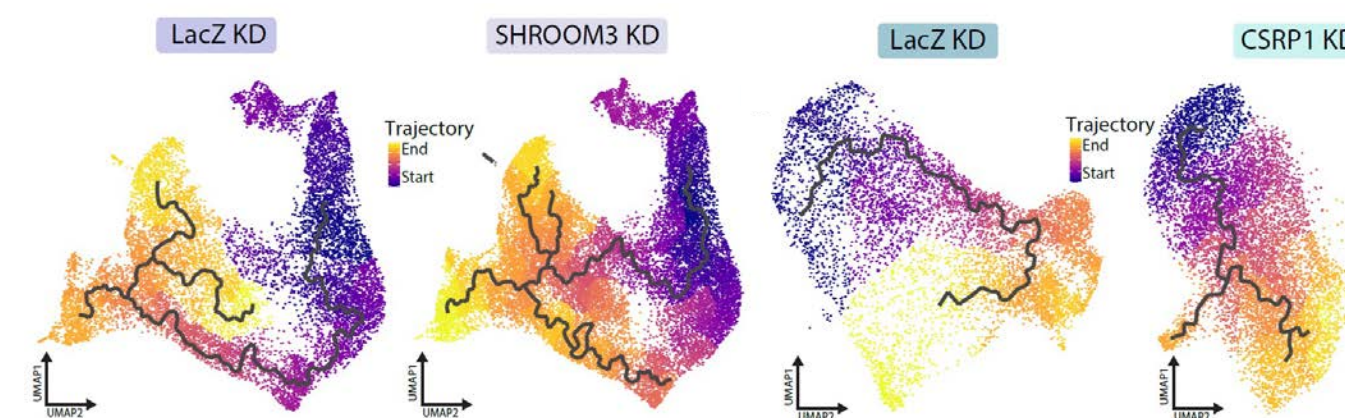
Measure

Example R1: Fetal membrane rupture, uterine rupture

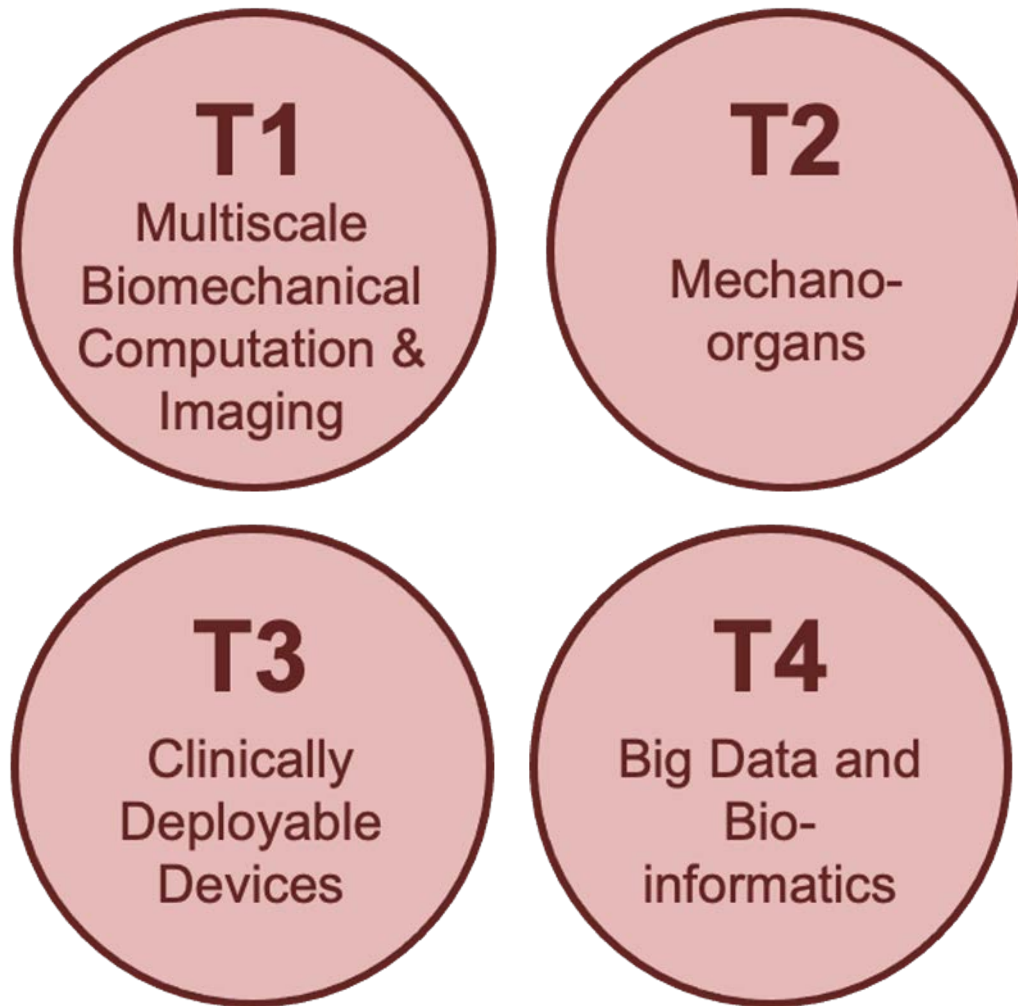


Model

Example R4: cell progression changes when specific parts of focal adhesions are deleted

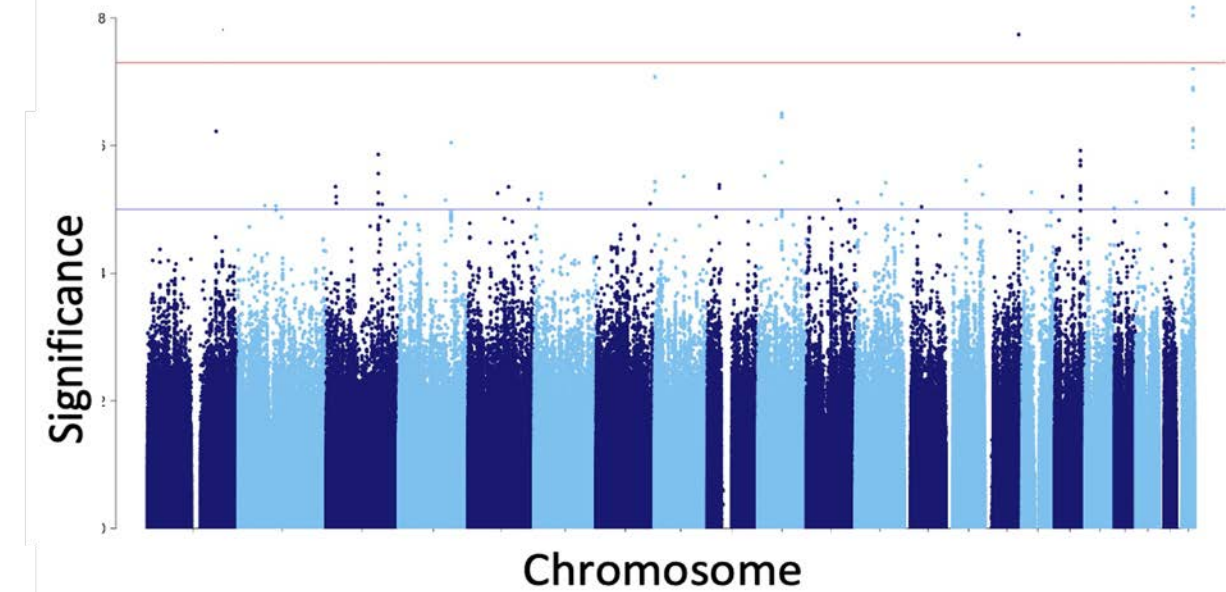



Enabling Technology Testbeds



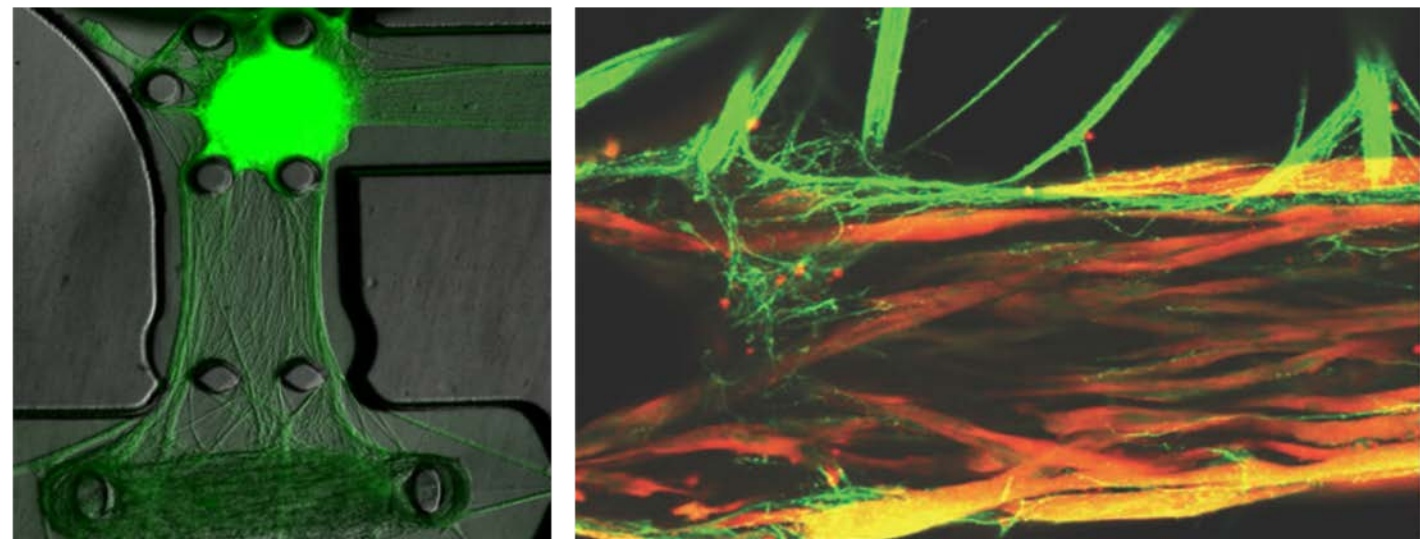
Model 

Example T4: Big Data and Bio-informatics



Make 

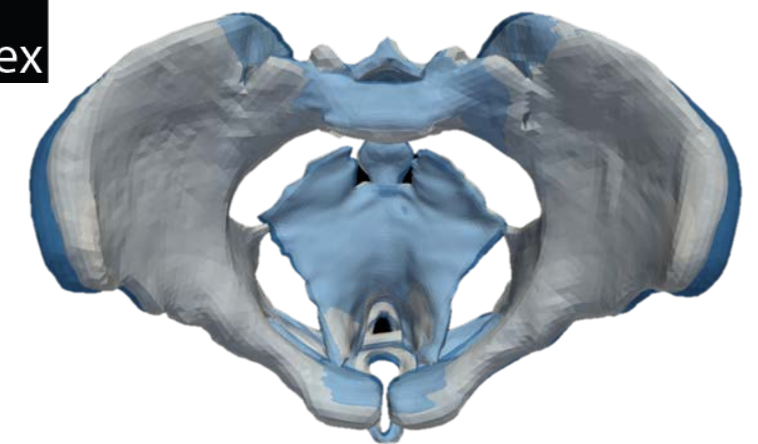
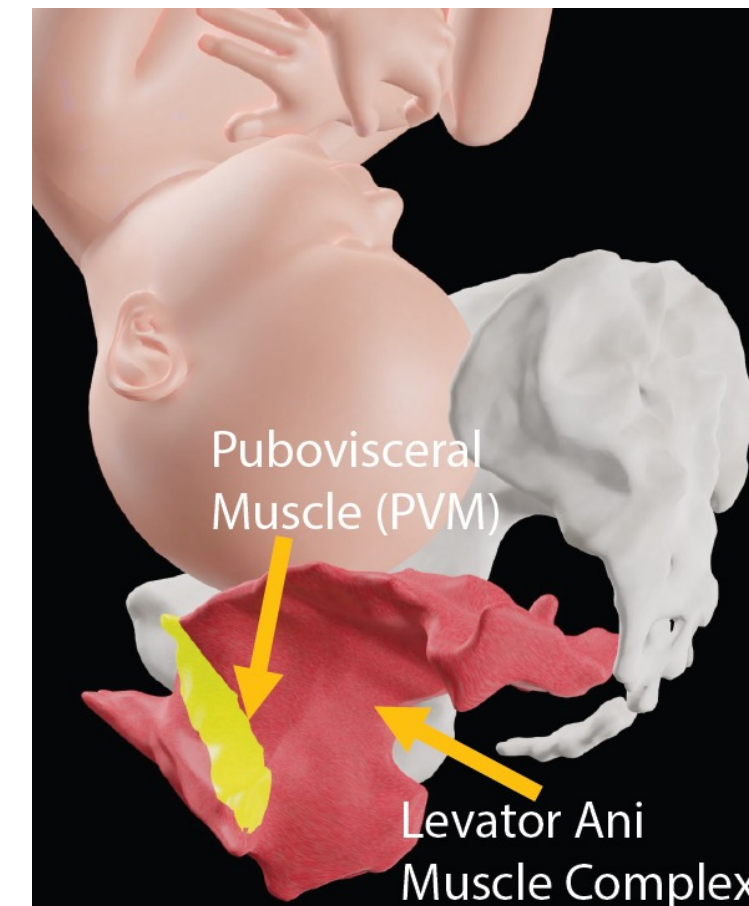
Example T2: Uterus on a chip



Systems Research Testbeds



Example Pelvic Health: subject-specific and population-informed solution to prevent pelvic floor disorders



Engineering Workforce Development + Diversity and Culture of Inclusion



Convergent Research

Innovation Ecosystem



Engineering Workforce Development

Diversity and Culture of Inclusion

The workforce lacks diverse women engineers, leading to disparities in patenting innovations for women's health

HISTORY OF INNOVATION

Who do we invent for? Patents by women focus more on women's health, but few women get to invent

Rembrand Koning^{1*}, Sampsa Samila², John-Paul Ferguson³

- Biomedical inventions from 1976 to 2010 identify a fundamental female inventor gap.
- Female inventors are 35% more likely to invent for women.

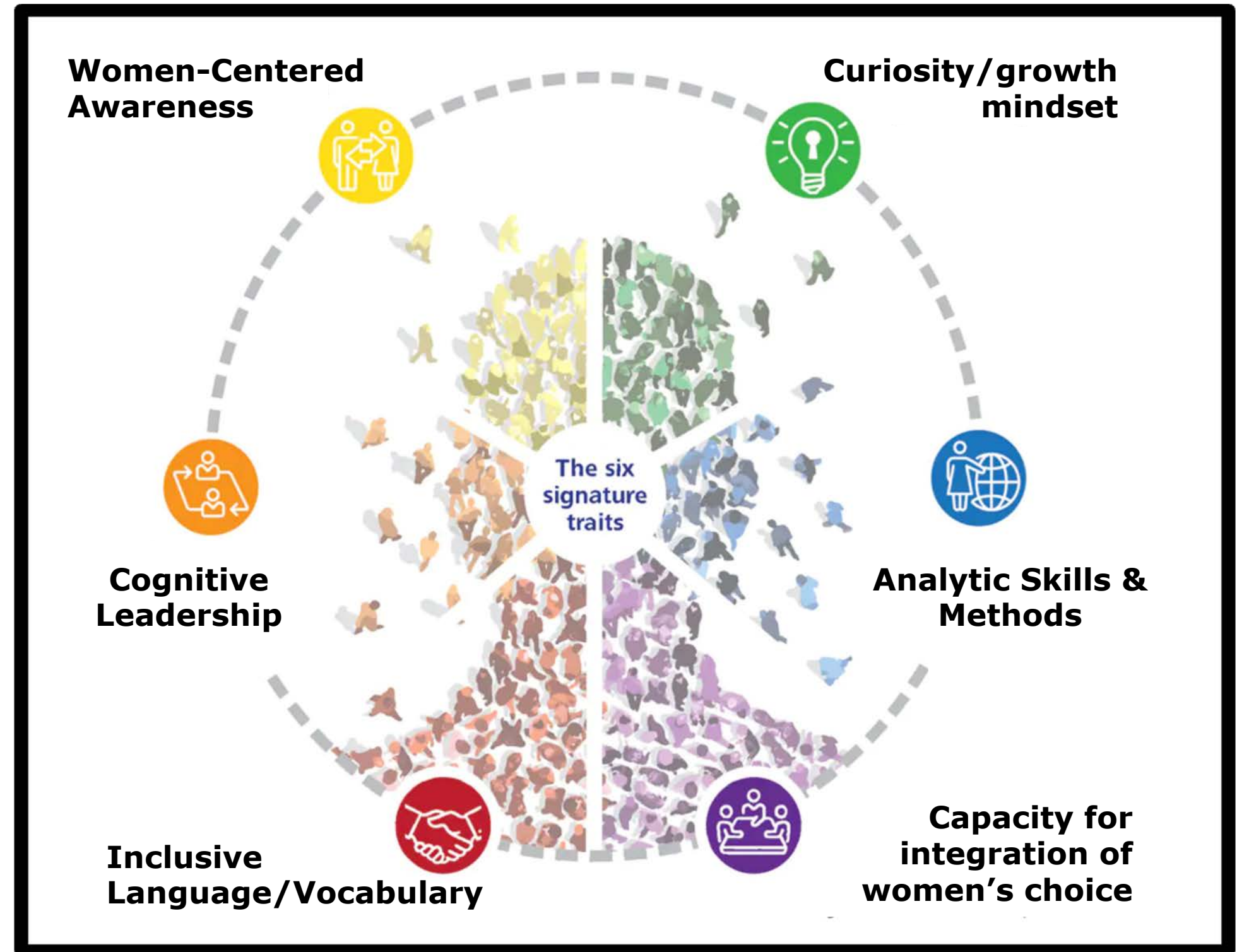
Society missed out on:

6,500 more female focused inventions

40,000 more female focused discoveries

Workforce Inclusion Module for Engaging the Next Generation (WIMEN)

- All training of EWD will center on six signature competencies related to inclusive excellence and women-centered engineering.



What are the primary activities of EWD?



Post-doc/early career

IMWEL Postdoctoral Experiences and Research Activities

NSF Advance Faculty Development Program

The Center for the Improvement of Mentored Experiences in Research (CIMER)



Graduate

Graduate Research within IMWEL Ecosystem

Entrepreneurship in Women's Health

Rising Stars in Engineering in Women's Health

Middle school

STEM and Women's Health Intervention through Pregnancy-center module



High School



NSF Research Experience of Teachers (RET)

Textbook Development

Undergraduate

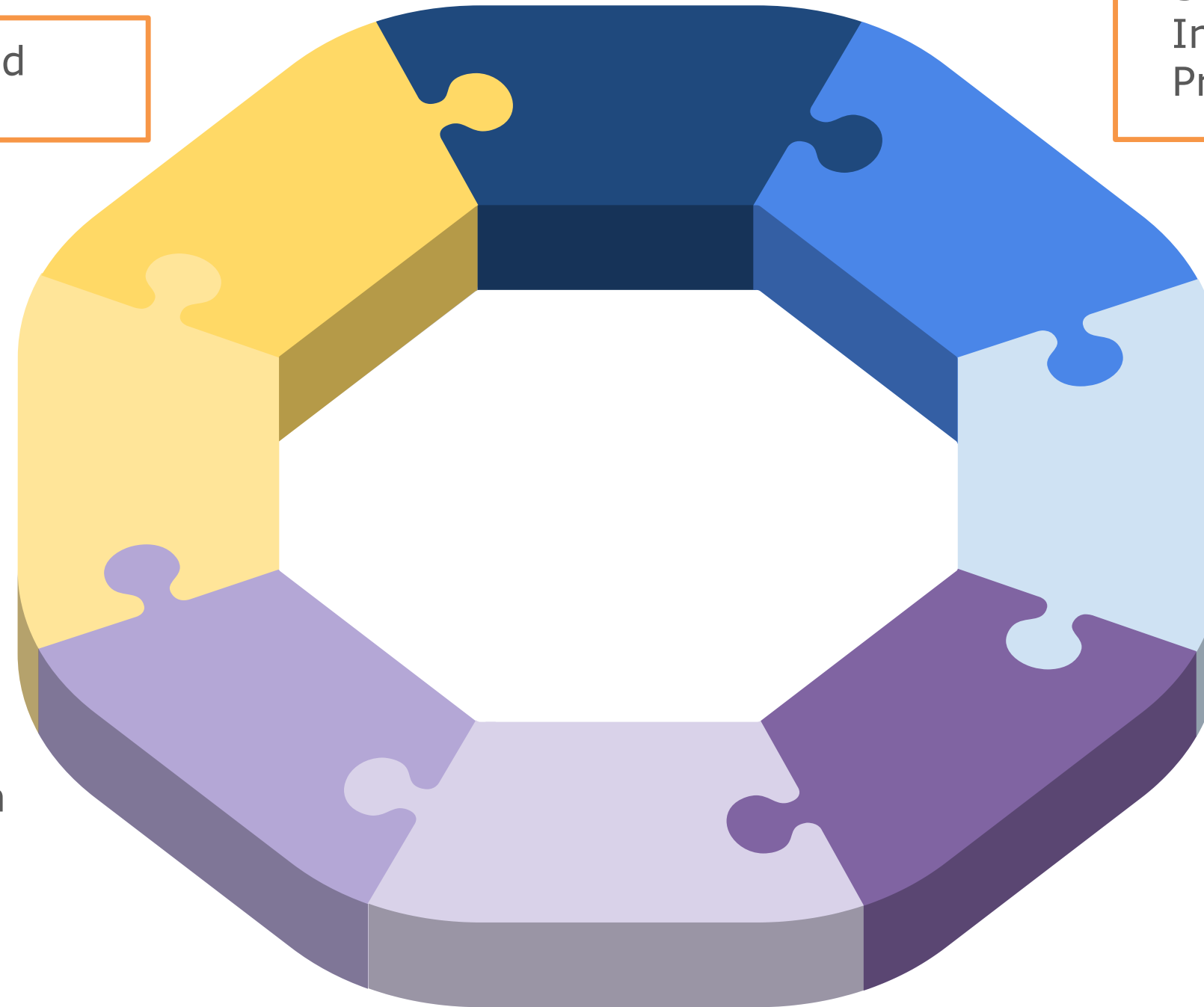


Curriculum interventions in freshman- and senior-level engineering courses

Senior Design Projects in Women's Health

Integration of Women's Choice in Technology Development

IMWEL Research Experience for Undergraduates (REU)



What are the primary activities of DCI?



Seed Grants

commit to a seed grant program where research can seek small amount of funds to diversify their samples and and/or analytic strategies



Community engagement plan

Authentically engage with the communities at each institution.



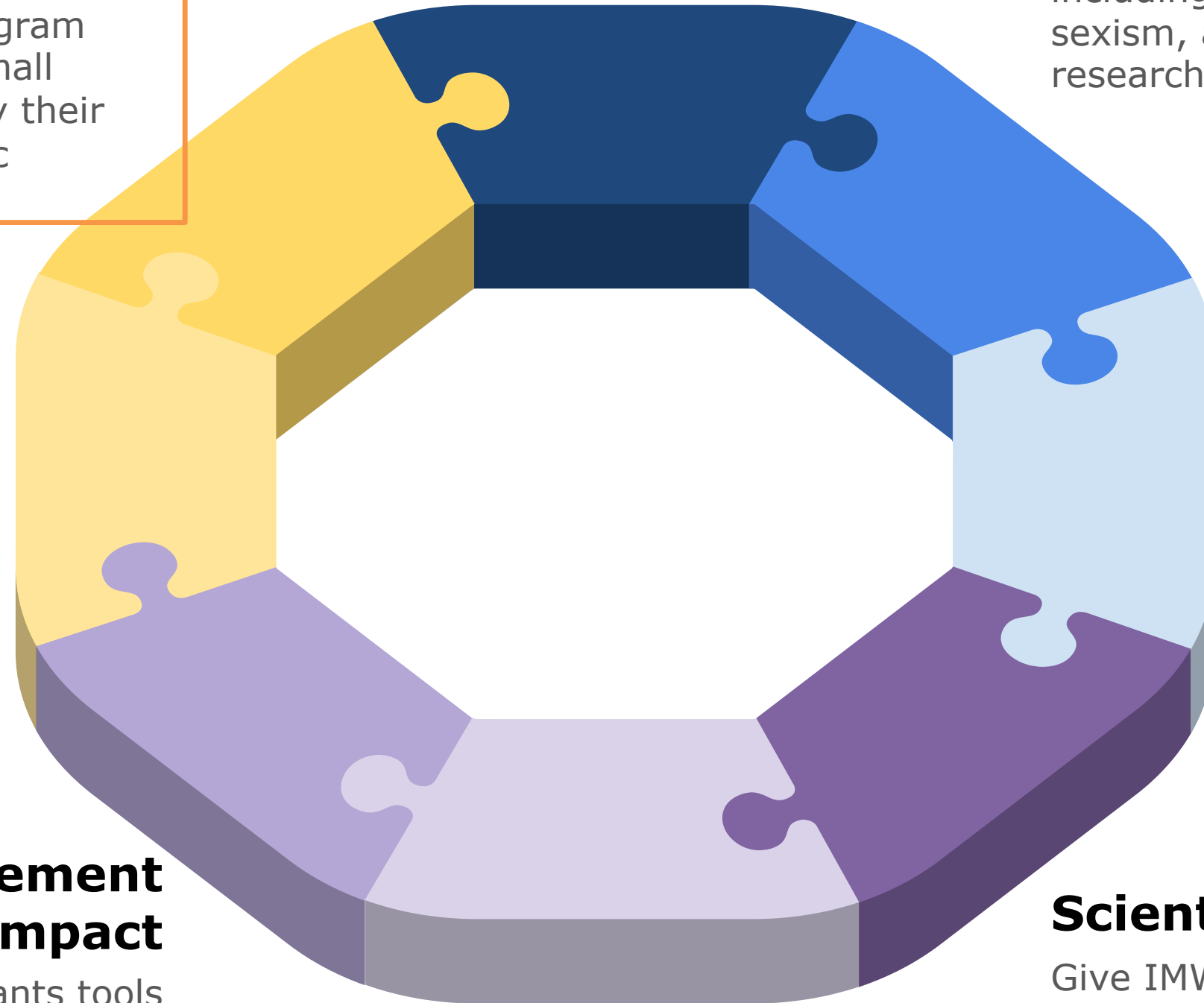
Product Design

Equip participants with the language and frame for addressing critiques about how to be gender and racially inclusive.

Community engagement impact



Give IMWEL participants tools for thinking about how to engage community in our work.



Provide historical context

This context will be provided over the life of the grant, including history of racism, sexism, and otherism in research on women's health



Clearinghouse of contemporary information

What do we know about health disparities and life circumstances of women today?



Inclusive Glossary

introduce glossary of inclusive common terms for IMWEL (e.g., woman vs. birthing people)



Scientific inclusion

Give IMWEL participants tools for thinking about sampling, methods, analyses and interpretation of their own analysis



DCI: Our approach



Sustained attention to evidence-based best practices is needed to foster, sustain and enhance a diversity, equitable and inclusive IMWEL climate.

Innovation Ecosystem



Harry West, CU

Mechanical Engineering, Industrial Engineering and Operations Research, Product Design Methodology, Service and Experience Design

Convergent Research

Innovation Ecosystem



Engineering Workforce Development

Diversity and Culture of Inclusion

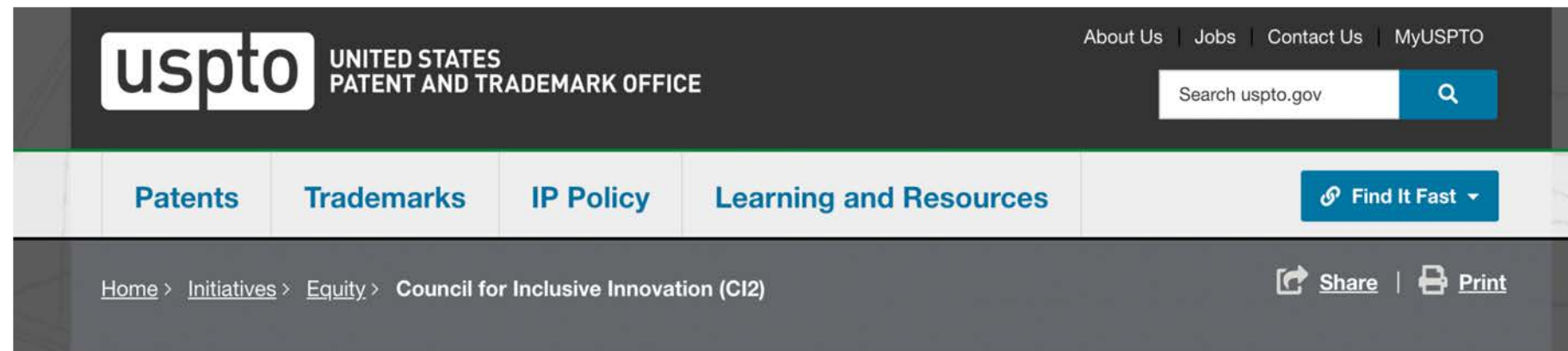


Women-centered approaches will enhance DCI and innovation ecosystem

We will learn, innovate, and teach **grounded in the voice of women.**

We will strive to improve the **health of all those who identify as women** and will benefit from the greater understanding of female physiology.

Innovation ecosystem activities will fill the inventor gap



Council for Inclusive Innovation (CI2)



- Promote culture of women-centered design
- De-risk and promote commercialization of women's health and mechanics-based projects
- Fund IMWEL Innovation Fellowships
- Catalyze IMWEL Maternal Health Startups via Fellowship program across the four sites

IMWEL Innovation Summit

- The IMWEL Innovation Summit will foster communication across the ERC, our partners and our community.
- Pairs annually with IMWEL's annual meeting
- Catalyzes innovation progress and ongoing engagement with our community throughout the year
- Brings together stakeholders including mothers of color and people who have been hurt in childbirth
- Enables the whole IMWEL community to:
 - Learn from each other
 - Share progress
 - Spark Lab to Market acceleration

IMWEL will incorporate Team Science to integrate all components, and continuously evaluate our success

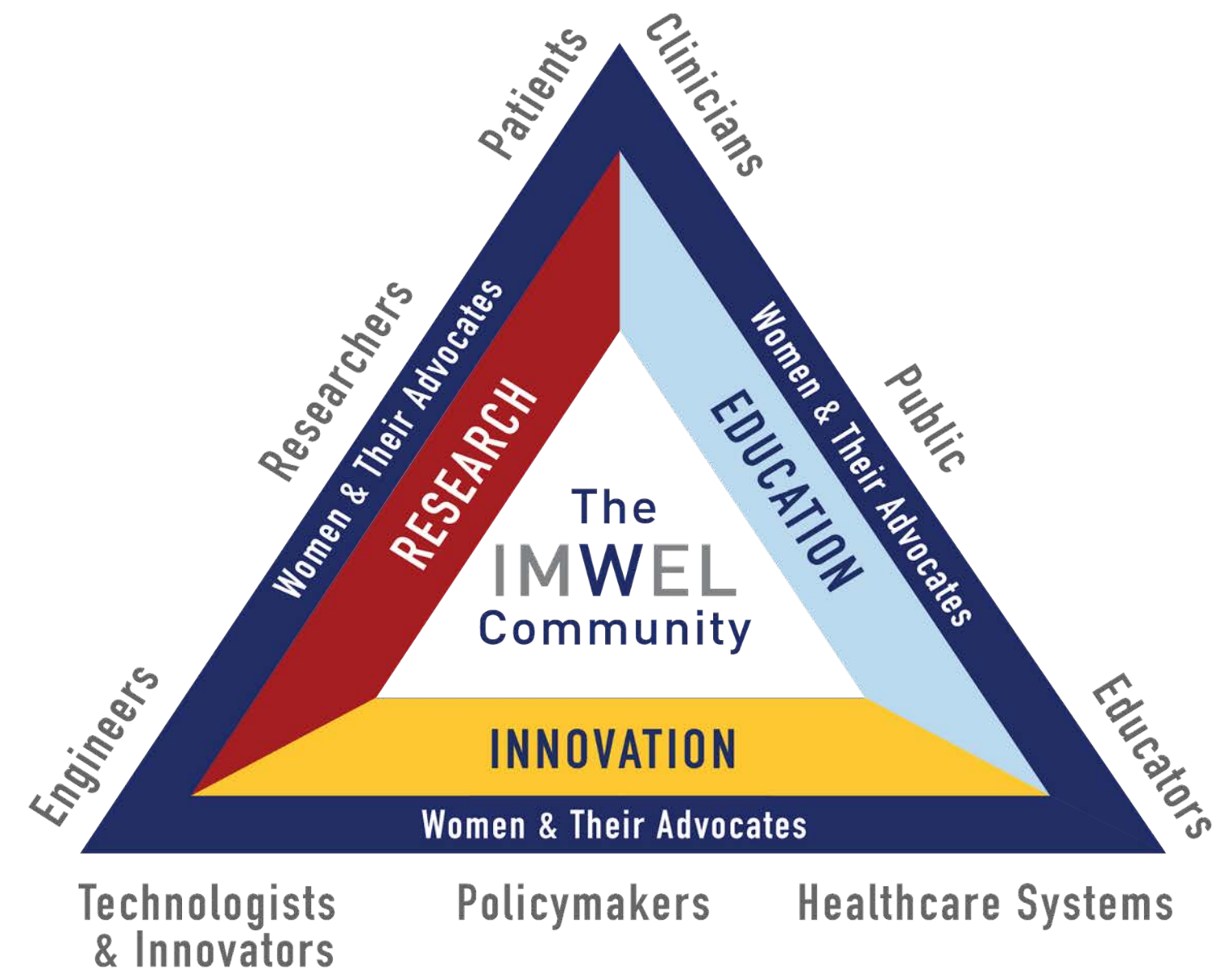


Women-centered women's health

- IMWEL will be a hub for academic, community, and industry to promote engineering excellence and innovation grounded in the voice and vision of the women we design for.

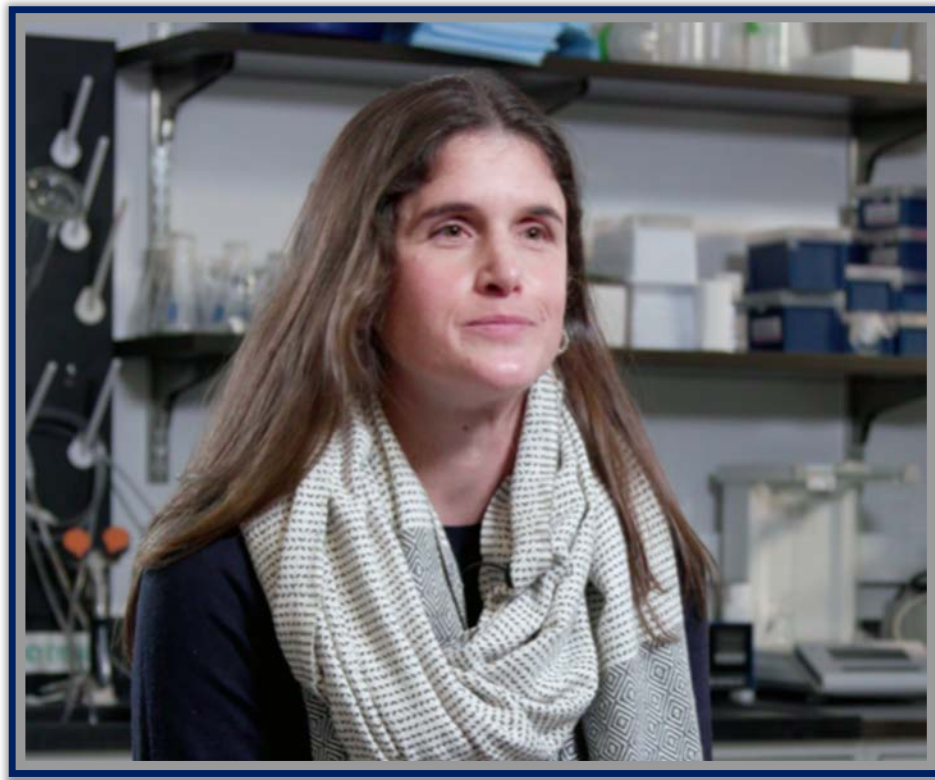
IMWEL

Community Impact Advisory Board



Brittney's story and hope for IMWEL

I've spent probably between three pregnancies close to a calendar year on bed rest.



Brittney Crystal
Founder Iris Fund
IMWEL community partner

Every gap in knowledge around women's health ends up being stress on the mom...

... “so maybe just go lay down,” which is financially impactful to the family, to the woman, to the whole community around them

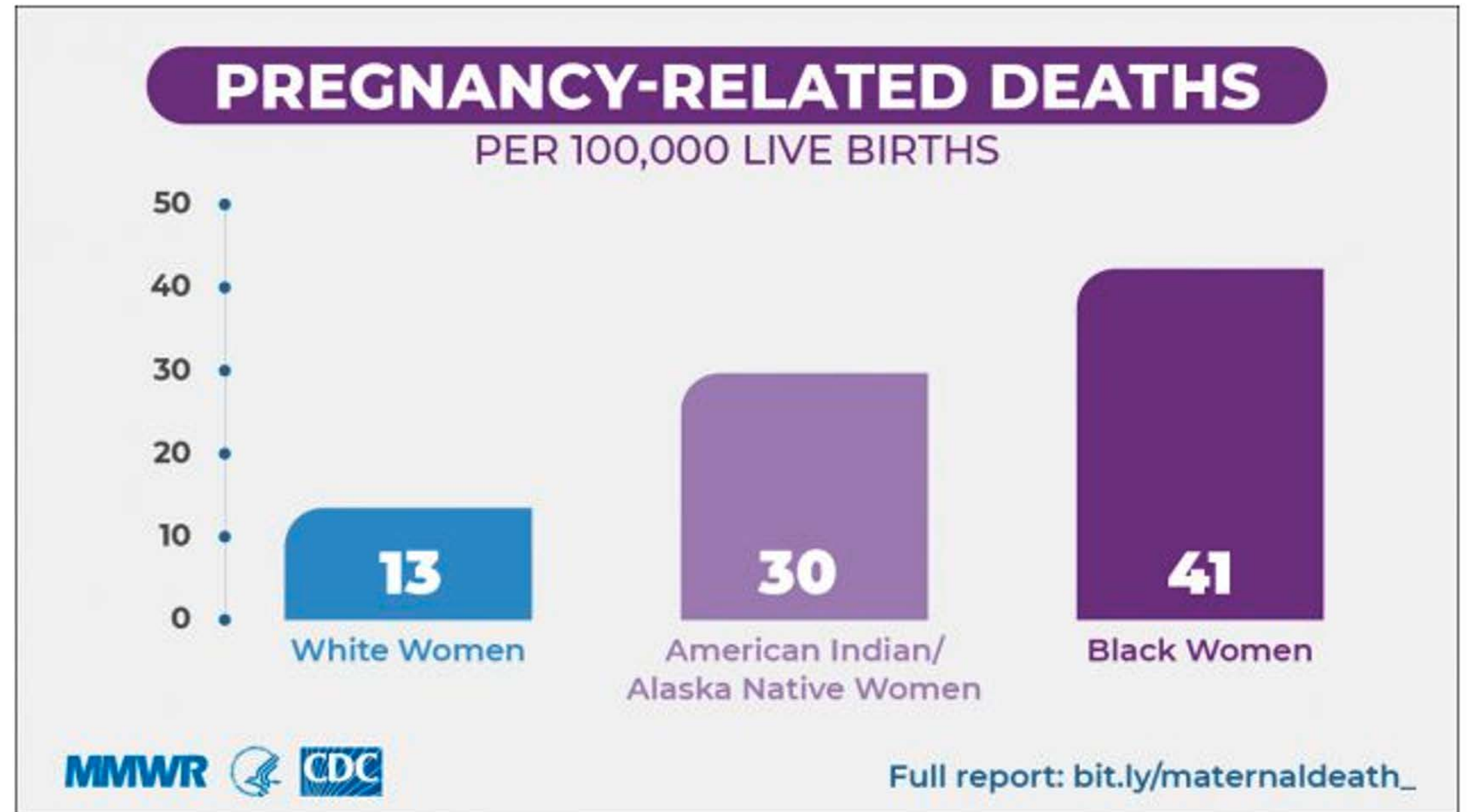
... and the idea that we can have a tool that's going to tell us about the stiffness, the strength of a cervix is really exciting to any high risk mom who's been on bed rest.

Director's Overview Q&A



The United States has one of the highest maternal mortality rates in the developed world

- Women die in pregnancy **4 times more in the US** than other developed countries.
- **Enormous racial disparities** exist in preterm birth and maternal health trends.



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