



IMWEL

Engineering Research Center
for Integrated Mechanobiology for
Women's Health

FACILITIES, EQUIPMENT AND OTHER RESOURCES

TABLE OF CONTENTS

1. IMWEL HEADQUARTERS	3
2. RESEARCH FACILITIES, EQUIPMENT & OTHER RESOURCES	4
A. COLUMBIA UNIVERSITY	5
B. EAST CAROLINA UNIVERSITY	29
C. UNIVERSITY OF CALIFORNIA, IRVINE	37
D. UNIVERSITY OF PITTSBURGH	43
3. TEAM SCIENCE RESOURCE	51
4. INNOVATION ECOSYSTEM FACILITIES, EQUIPMENT & OTHER RESOURCES	52
A. COLUMBIA UNIVERSITY	52
B. EAST CAROLINA UNIVERSITY	55
C. UNIVERSITY OF CALIFORNIA, IRVINE	56
D. UNIVERSITY OF PITTSBURGH	57
5. ENGINEERING WORKFORCE DEVELOPMENT AND DIVERSITY & CULTURE OF INCLUSION RESOURCES	57
A. COLUMBIA UNIVERSITY	57
B. EAST CAROLINA UNIVERSITY	57
C. UNIVERSITY OF CALIFORNIA, IRVINE	58
D. UNIVERSITY OF PITTSBURGH	59
6. COMMUNICATIONS AND DATA STORAGE	60
7. OTHER RESOURCES: IMWEL Partners	61



Space Grade Level		Actual
Yellow	Dry	3,439.4 SF
Blue	Wet	5,368.8 SF
	SUBTOTAL	8,808.2 SF
	NOT DESIGNATED	26.0 SF
	TOTALS	8,834.3 SF

Lasker Building
 390 Broadway New York, NY 10032-1543
 5th Floor
 Portfolio: As Built
 Date: Jul 18, 2019

Figure 2: IMWEL Headquarters

IMWEL's headquarters includes access to a reception room (540), a Conference room (517) that seats twelve at a table with room for another dozen along the sides, and lunch rooms on both floors (430D & 502). IMWEL will also have access to Freezer Rooms on both floors (430B & 504), a Machine Shop/Makerspace (515), Ice Machine in the Equipment Room (514), and glasswasher and autoclave in the basement. IMWEL may also use a first floor Conference Room similar to the 517 space.

The six story Lasker building has 24-hour Public Safety guard service, swipe access and security cameras, a loading dock and freight elevator, WIFI throughout. Situated in the Lasker building, IMWEL will also have access to a first floor conference room that can seat up to 30 people.

2. RESEARCH FACILITIES, EQUIPMENT & OTHER RESOURCES

A. COLUMBIA UNIVERSITY

Columbia University is the oldest institution of higher learning in New York State and the fifth oldest in the United States, founded by royal charter in 1754 as King's College and changed to Columbia in 1784. The Vagelos College of Physicians & Surgeons (VP&S), founded in 1767, was the first American school to award the MD degree in 1770. In 1864, Columbia founded the country's first mining school, a precursor of today's Fu Foundation School of Engineering and Applied Science, and awarded the first Columbia Ph.D. in 1875. In 1928, Columbia-Presbyterian Medical Center became the first center to combine teaching, research and patient care as a joint project between the medical school and The Presbyterian Hospital. Today, Columbia performs over \$1B of research annually, much of it for the Federal Government.

Columbia is home to approximately 31.5K students, including 8.8k undergraduates, and 4.4k full-time faculty. The Engineering School includes 1.7k undergraduates and 4.1k graduate students taught by 235 faculty. Forty-five percent of the University student population as a whole self-describes as a minority. Within Engineering, 43% of the graduate students and 65% of the undergraduates self-describe as a minority. The undergraduate class of the University as a whole of 2023 is 49% male and 51% female, 54% Caucasian, 30% Asian or Pacific Islander, 20% Hispanic, 15% African American, 3% Native American and 1% unknown. Citizens from 74 countries make up 16% of the class and 18% are first generation to attend college. Columbia also has the largest number of veterans of any of the Ivy League institutions.

Columbia's main campus centered between 110th and 120th, Broadway and Morningside Drive is located in the Morningside Heights section of Harlem. Its Medical Center is located two miles north in Washington Heights in upper Harlem, with the new Manhattanville campus situated approximately in between, all linked via the #1 Subway Line and Broadway buses.

RESEARCH FACILITIES--Columbia University

Dr. Advincula's Laboratory Facilities

Columbia University Irving Medical Center

Columbia University Medical Center (CUIMC) is one of the nation's top-ranked medical universities. It provides national and global leadership in scientific research, health and medical education, and patient care. CUIMC provides a collaborative research environment with many centralized resources that are available to researchers. Several key components of CUIMC integral to the success of this project are outlined below:

Department of Obstetrics & Gynecology

The Columbia Department of Obstetrics & Gynecology faculty has demonstrated skill in organizing and participating in research and is among the top departments in the country in this area currently ranking #11 in NIH funding. It has a strong, proven track record of collaboration at every stage, ranging from design, implementation, data analysis, and dissemination of findings. Productivity is facilitated by a number of factors including:

- A critical mass of academic full time faculty with sufficient time and skill to perform clinical research
- A large population of medical students and residents/fellows (house staff) available as subjects for this study on surgeon training in laparoscopy
- The presence of a diverse patient population willing to participate in research initiatives

- An established research environment in which clinicians accept participation in research initiatives as a major role of a teaching institution.

Of utmost importance is the preexisting integrated research infrastructure with a proven record of success which is complemented by the large and diverse population, elaborate system of clinical care, advanced support systems, strong division of Gynecologic Specialty Surgery, and a patient population proven to be receptive to participation in research.

Division of Gynecologic Specialty Surgery

The Division of Gynecologic Specialty Surgery at Columbia University offers patients comprehensive gynecologic surgical care, including a wide range of consultation and treatment options, from routine testing to the most advanced diagnosis and treatment for women of all ages. All physicians hold academic appointments at Columbia University's College of Physicians and Surgeons and have completed an accredited residency training program. Many have completed sub-specialty training in robotic surgery, female pelvic floor disorders, infertility, and advanced laparoscopic surgery. They work closely with specialists throughout NewYork-Presbyterian Hospital/Columbia University Irving Medical Center (NYP/CUIMC) to coordinate care, if necessary.

The surgeons employ the latest technologies to treat various female reproductive tract disorders. They provide surgical care for adults, children, and adolescents; strive to take the least invasive approach to surgery whenever possible; and regularly use hysteroscopic, laparoscopic and robotic techniques to minimize patients' recovery times. The division last year performed 54 vaginal hysterectomies and 112 pelvic reconstructive surgeries. The division is also committed to the training of Minimally Invasive Gynecologic Surgical (MIGS) Fellows who are not only well versed in the technical aspects of surgery but also the pedagogical aspects through the use of surgical simulation.

The standard of excellence the physicians bring to patient care matches the standards they have established in medical student education and world-class academic research. US News & World Report ranks Columbia's College of Physicians and Surgeons, Columbia University's medical school, among the top institutions nationally for women's health and for research and specifically the Gynecology program in the top 5.

As part of the vibrant medical community at CUIMC, the doctors and patients benefit from NYP/CUIMC's facilities and expertise in patient care, collaboration with cutting edge medical researchers, clinicians and multidisciplinary specialists. NYP is consistently ranked #1 in New York City, included on the national Honor Roll, and listed in the top 10 for gynecology in US News and World Report's 2011-2012 survey.

Central Department Research Administrative Office

The Department of OB/GYN maintains a centralized administrative research office that manages pre- and post-award grant administration, and oversees roughly \$10 million in sponsored research funding annually. Led by the Senior Director of Research Administration, who supervises all administrative functions of research in the Department of OB/GYN, the

Central Department Research Administrative Office has managed many large, complex multi-centered projects and participates in a number of multicenter networks and federal contracts.

The Office analyzes, monitors, and evaluates the Department's pre-award, post-award, and research activities including all federal and non-federal sponsored projects and contracts. They ensure the efficient, cost-effective administration and financial management of grants and contracts throughout the Department in compliance with internal and external policies and procedures. The Office also ensures proper account set-up for sponsored activities. They develop and implement standard operating procedures, administrative systems, and departmental policies and procedures to ensure award guidelines and regulations are met. They actively communicate these policies and procedures to the Department faculty and staff. The Office also ensures that they are up-to-date on all current administrative policies and technologies to maintain compliance and a competitive advantage.

Mary and Michael Jaharis Simulation Center

Columbia University Medical Center's new, state-of-the-art medical and graduate education building, the *Roy and Diana Vagelos Education Center*, is home to the *Mary and Michael Jaharis Simulation Center* to reflect how medicine is taught, learned and practiced in the 21st century. This 20,000 square foot facility is designed to reshape the look and feel of the Medical Center campus and to create spaces that facilitate the development of skills essential for modern medical practice and is a major training resource that integrates our standardized patient program, mannequin-based simulations and procedural skills training through the use of both low and high fidelity simulators. Foundations Seminars and Tutorials will incorporate a sequence of OSCEs to help guide students in developing their clinical skills in preparation for the Major Clinical Year. Clerkship OSCEs will transition into the SIM Center over the coming year. The Step 2 Clinical Skills preparation program will launch in the SIM Center as will Ready 4 Residency simulations and skills sessions. The SIM Center staff is also dedicated to providing enriching, positive learning experiences to all types of learners and is happy to work with faculty (in this case Obstetrics & Gynecology Specialists) to develop new curricular offerings that meet their training needs.

A crown jewel within the simulation center is the 30 station Anatomy/Bioskills laboratory which houses not only multiple surgical simulators but also will allow for the testing of study subjects on the actual simulated procedures performed in clinical practice. Integrated into this facility is the ability to do seamless global videoconferencing and telementoring (within and outside of the medical campus). State-of-the-art 3-D printing capability is also located within the center as part of the precision medicine and technology innovation/acceleration program.

Dr. Ateshian's Laboratory Facilities

Musculoskeletal Biomechanics Laboratory

Dr. Ateshian directs this laboratory which occupies 1,000 square feet of floor space in the Fu Foundation School of Engineering and Applied Science, Room 134A Mudd Building, 1st floor. It contains several custom-designed devices for testing the biomechanical and tribological properties of cartilage and other soft tissues and gels, and the osmotic pressure of macromolecular solutions. Tissue testing modalities include tension, compression, shear, the assessment of frictional properties and wear, and hydraulic permeability. These instruments incorporate various high accuracy stepper- and servo- motors, voice-coil actuators, and load,

torque, pressure and displacement transducers, including three multi-axis load cells (two Model 20E12A-M25B and one Model 45E15A4-U760-EF, JR3, Inc., Woodland, CA) and three high precision translation stages (Model PM500-1L, Newport Corporation, Irvine, CA; Model Tolomatic Linear Actuator, Action Automation & Control, N. Attleboro, MA). Also available is a digital video camera (Model SSC-C50A, Sony America, New York, NY) and stereoscope (Model SZ40, Olympus). A laser 3D scanner (NextEngine Inc., Santa Monica, CA) with a rated accuracy of 125 μm can produce a dense point cloud (160 points/cm) of any desired geometry with a field size of 5.1"×3.8". Particulate sizing and counting in the range 0.4 μm to 1.6 mm is possible with a Coulter Counter (Multisizer 4, Beckman Coulter, Brea, CA). A freezing-stage sledge microtome (Model 1400, Leitz, Rockleigh, NJ) is available for cryosectioning. Fluid shearing can be performed using peristaltic pumps with precision digital speed control (Manostat Vera, Barnant Company, Barrington, IL). SDS-PAGE can be performed using a gel electrophoresis system and blot module for western blotting (Novex-NuPAGE, Life Technologies, Carlsbad, CA). A Class II Biosafety Cabinet (Labconco, Kansas City, MO), CO₂ incubator (Thermo Fisher, Waltham, MA), -25°C freezers with combined capacity of 25 cu.ft, a refrigerator, centrifuge (Model 5804, Eppendorf, Hamburg, Germany), balances, and other ancillary equipment for preparing testing solutions and test specimens, as well as multimeters, analog filters, and other electronic equipment, are also available.

Computer

The Musculoskeletal Biomechanics Laboratory computer resources consist of six Dell desktop computers with 12 to 24 GB RAM, data acquisition and motion-controller cards (National Instruments, Austin, TX) and LabView data acquisition and control software (National Instruments), four Apple iMac 21.5" display with Intel Core i7 and 2.8/3.1 GHz Quad-core 16 GB memory, one Apple Mac Pro Xeon with two 3.2 GHz Quad-core Intel Xeon 8-core, 8 GB memory and 300 GB SAS drive, with Apple Cinema HD 30" flat panel display, and Apple iMac 27" display with Intel Core i7 and 4.0 GHz Quad-core 32 GB memory for computational analyses. A 10TB network data server (Synology, Redmond, WA) provides data backup and storage. On all computers a variety of software is available allowing computer aided design (ProE – PTC, Needham, MA; SolidWorks, Concord, MA), numerical analysis (Matlab – Mathworks, Natick, MA), image-based strain measurement (Vic2D – Correlated Solutions, Columbia, SC), finite element analysis (FEBio, PreView, PostView), and finite element mesh generation (CUBIT).

Office

The primary office for Dr. Ateshian is located in Room 244 Mudd.

Equipment

- Three multi-axis load cells (two Model 20E12A-M25B and one Model 45E15A4-U760-EF, JR3, Inc., Woodland, CA)
- Three high precision translation stages (Model PM500-1L, Newport Corporation, Irvine, CA; Model Tolomatic Linear Actuator, Action Automation & Control, N. Attleboro, MA).
- Digital video camera (Model SSC-C50A, Sony America, New York, NY)
- Stereoscope (Model SZ40, Olympus)
- Laser 3D scanner (NextEngine Inc., Santa Monica, CA) with a rated accuracy of 125 μm can produce a dense point cloud (160 points/cm) of any desired geometry with a field size of 5.1"×3.8"
- Coulter Counter (Multisizer 4, Beckman Coulter, Brea, CA) for particulate sizing and counting in the range 0.4 μm to 1.6 mm
- Freezing-stage sledge microtome (Model 1400, Leitz, Rockleigh, NJ) for cryosectioning

- Peristaltic pumps with precision digital speed control (Manostat Vera, Barnant Company, Barrington, IL)
- SDS-PAGE can be performed using a gel electrophoresis system and blot module for western blotting (Novex-NuPAGE, Life Technologies, Carlsbad, CA)
- Class II Biosafety Cabinet (Labconco, Kansas City, MO)
- CO₂ incubator (Thermo Fisher, Waltham, MA),
- -25°C freezers with combined capacity of 25 cu.ft, a refrigerator
- Centrifuge (Model 5804, Eppendorf, Hamburg, Germany)

Other Resources

Mechanical Engineering Machine Shop (Room 279, Engineering Terrace, 2nd floor): This machine shop is located in the Department of Mechanical Engineering. It is equipped with three three-axis vertical milling machines, three lathes, a Fadal VMC 15 computerized numerical control (CNC) vertical machining center, a grinder, a Brown and Sharpe coordinate measuring machine (CMM), an FDM 2000 rapid prototyping machine, and various bandsaws and other machining tools.

Dr. Azizi's Laboratory Facilities

The Azizi Lab is jointly affiliated with the Biomedical Engineering (BME) Department and the Irving Institute for Cancer Dynamics (IICD) at Columbia University. The BME department was established in 2000 and its research facilities and lab spaces are primarily located in the Mudd Building in the Morningside campus. IICD was recently established in 2018 to focus on the interplay between mathematical sciences and cancer research and its offices and facilities are located in the Schermerhorn Hall also in the Morningside campus at Columbia University. Dr. Azizi is also a member of the Irving Comprehensive Cancer Center located in the Columbia University medical campus.

Laboratory

The Azizi Lab consists of two components. The computational (dry) lab space located on the 3rd floor of the Mudd Building in the Morningside campus totals 247 sq. ft. and includes office space for students, postdocs and research staff. The experimental (wet) lab space located on the 5th floor of the Lasker building in the Columbia University medical campus totals 717 sq. ft. includes molecular bench lab space, tissue culture room, office space for staff and students and shared equipment room. A station will be allocated in the wet lab space for high throughput single-cell encapsulation and barcoding for RNA sequencing.

Equipment

Major equipment in the experimental lab will consist of liquid nitrogen sample storage unit, -80 and -20 freezers, an Eppendorf centrifuge, Bioanalyzer, a SimpliAmp PCR system, gentleMACS dissociator, Nikon TS100 microscope, and 10X Genomics Chromium Single-Cell Controller for single cell RNA sequencing protocols.

Computer

The PI has a personal mac pro desktop workstation with 64 GB memory and 2.7GHz 12-core processor. She and her group will also have access to mac pro laptops with 16GB memory and 2.9 GHz core i7 processor.

High-Performance computing:

The PI has set up a Google Cloud platform for the lab with access to a wide range of CPUs, high memory machines as well as GPUs.

Shared Core Facilities at Columbia University

Computational Infrastructure:

The computational analysis of data will be performed using the CUIT High performance Computing (HPC) service at Columbia University as well as Google Cloud Platform set up for the Azizi lab. The IICD institute also purchased two Standard Nodes (Dual Skylake Gold 6126 processors (2.6 GHz, 12 cores each, 24 cores per server), 192 GB memory, EDR Infiniband, 480 GB SSD drive), two High Memory Nodes (Dual Skylake Gold 6126 processors (2.6 GHz, 12 cores each, 24 cores per server), 768 GB memory, EDR Infiniband, 480 GB SSD drive) and one GPU Server with one V100 32GB Module with Dual Skylake Gold 6126 processors (2.6 GHz, 12 cores each, 24 cores per server), 192 GB memory, EDR Infiniband, 480 GB SSD drive, and one Nvidia 32GB V100 GPU), and 20Tb of scratch storage. This infrastructure supports all IICD hires.

Next-Generation Sequencing Core:

The data proposed in this project will be collected by collaborators and the Azizi lab. In all projects, the Azizi lab will receive de-identified data or de-identified samples from clinical cohorts. Library preparation and next-generation sequencing would be performed using the Illumina HiSeq 2500, MiSeq, and NextSeq platforms at the Columbia Genome Center. The genomic libraries will be generated in the Azizi lab and the Genome Center performs sequencing at-cost through self-service runs on these sequencing platforms.

Dr. Guo's Laboratory Facilities

Bone Bioengineering Laboratory

This 800-square-foot laboratory is located in the Biomedical Engineering Department. Studies in the laboratory focus on imaging and morphological analyses of bone microstructure, computational bone mechanics, and the quantification of cellular and molecular mechanisms of bone response to mechanical stimulation, with clinical implications of the mechanical properties of bone tissue in various bone pathologies. The laboratory is equipped with state-of-the-art facilities and software for biomechanical and biological studies of skeletal tissues, including: an MTS 810 servo-hydraulic Material Testing Machine with various extensometers, two Bose ElectroForce 5500 mechanical testing machines with a variety of load cells and supplementary attachments for *in-vivo* and *ex vivo* loading, an *in vivo* micro-computed tomography system (VivaCT 80) for small animals and *in vitro* specimens with nominal resolution of 10 μm and dedicated HP Professional Workstation DS25E (1x1GHz processors), 19" TFT Monitor, 18.2 and 72 GB hard drives, 10 GB RAM, 40/80 GB DLT Tape Drive (DLT8000), a HP Integrity Server rx2660 with dual cores (2X1.4 Ghz CPU), 4x8 RAM, 24" TFT Monitor and 4x300 GB SCSI drives, precision specimen preparation components, a meat band saw, a drill press, mini-lathe, and mini-milling machine for device manufacturing and specimen machining, stereo microscope, a micro-tester for microindentation studies of biological materials, PCs with built in video board and LabView data acquisition software, D/A data acquisition board, histology/morphology preparation equipment, vacuum oven, two upright polarized/fluorescence transmitted and reflected light microscope with OsteoMeasure bone histomorphometry system, CCD video camera, polisher, 4 PC Workstations loaded with image analysis/finite element software (HyperMesh, ABAQUS, DYNA 3D, AVS, MATLAB, IMSL Fortran Library), a finite element analysis program using FAIM 6.0 (Numerics 88, Calgary, Alberta) on a desktop workstation (Linux Ubuntu 12.10, 2x6-core Intel Xenon, 64GB RAM) with an internal graphics processing unit (nVidia Tesla C2075, 6GB), 1 windows server with dual core CPUs and 4.2 TB disk storage space, 1 powerful computation server equipped with 2x6 CPUs and 128 GB RAM, four Dell personal computers with office, graphics, and statistical software, *in vivo* animal experimentation equipment, and an *in vivo* servo-feedback controlled mechanical stimulator. Other equipment includes a small-animal anesthesia machine, a BioRad real-time PCR machine for gene expression analysis, a BioRad mini Western blot

system for protein expression, two refrigerators/freezers, two freezers (-20°C), a Forma culture incubator, a laminar flow biological safety hood, a fume hood, three incubators, a Reichert hard tissue microtome, a feed-back controlled *in vitro* bone explant mechanical loading system, a perfusion system for tissue culture, a steady fluid flow chamber, and a dynamic oscillating fluid flow chamber for cell mechanotransduction studies. This laboratory is also equipped with a custom built tibia loader for *ex vivo* experiments, including displacement transducers and data acquisition cards controlled by LabView software.

Microscopy Room, Bone Bioengineering Laboratory

The cell imaging equipment in the lab includes a custom built “multi-emission quasi-3D microscope” consisting of an Olympus upright (BX2)/inverted (IX71) fluorescence microscopy system, two Andor EMCCD high resolution CCD cameras with high sensitivity in the visible/near-IR capabilities, a motorized microscope stage, 2 sets of Olympus microscope objectives including 10X, 20X, 40X, and 60X Olympus LUCPLANFL Long Working Distance objectives with coverslip collar correction, a Lambda DG-4 Ultra High Speed Wavelength Switcher xenon light source with 175W output, an Olympus U-LH100 Mercury light source attached to the upright microscope, a near-IR LED light source, 2 sets of custom built Photometrics Quadview beamsplitters with Chroma dichroics and emission filters allowing simultaneous acquisitions of CFP, YFP, mcherry/mkate2, and near-IR emissions. Universal Image Metamorph 7.6.4 software controls the cameras and light source shutters.

Biomedical Engineering Freezer Room

Located in room 370 at Engineering Terrace in the Fu Foundation School of Engineering and Applied Sciences, the freezer room represents 150 sq. ft. of renovated laboratory space housing a -80°C freezer, double-door -20°C freezer, double-door refrigerator, steam autoclave, ice machine, and stainless steel tables for specimen thawing and tissue dissection.

Biomedical Engineering Machine Shop

The 350-square-foot machine shop is operated by a full time machinist, and is fully equipped with a CNC mill and other major tools, which can also be operated by trained personnel. In addition, the Mechanical Engineering Department has a rapid prototyping facility available for engineering students and faculty.

Equipment

Located in the Principal Investigator and Center Director Dr. Guo’s Bone Bioengineering laboratory, there is a micro computed tomography system (VivaCT 80, Scanco Medical AG), which has the capability to scan human bone at a resolution between 10 – 76 µm. The scanner is equipped with two powerful processing servers for structural evaluations: one HP Alpha workstation equipped with one 1 GHz processor, 19" TFT Monitor, 18.2 and 72 GB hard drives, 40/80 GB DLT Tape Drive (DLT8000); the other one is a HP Integrity workstation equipped with dual core processors (1.4 GHz), 4x8 RAM, 24" TFT Monitor, 4x300 GB SCSI drives and a 1.5/3 TB Quantum LTO Tape Drive.

In the same room owned by the Principal Investigator and Center Director Dr. Guo, there is a material testing machine (MTS810). This material testing machine has the capability to perform uniaxial compression/tension and bending tests. The machine is equipped with load cells which can measure as high as a 100 KN load and multiple extensometers to measure strain.

In the room owned by the Principal Investigator and Center Director Dr. Guo, there is another desktop workstation (Linux Ubuntu 12.10, 2x6-core Intel Xenon, 64GB RAM) with an internal graphics processing unit (nVidia Tesla C2075, 6GB). The desktop workstation is installed with

finite element software (FAIM 6.0, Numerics 88, Calgary, Alberta), which has the capability to process linear finite element analysis at the level of 100 million elements size.

Dr. Hendon's Laboratory Facilities

Structure Function Imaging Laboratory

Dr. Hendon directs the Structure-Function Imaging Laboratory comprising 600 square feet of laboratory space, which is dedicated to the development and clinical translation of novel optical imaging technologies. Dr. Hendon's laboratory is within the Electrical Engineering (EE) Department located on the main campus of Columbia University, in the Schapiro Center for Engineering and Physical Science Research: 530 West 120th Street, New York NY. The EE Department's location is in close proximity to Columbia Medical Center. The Morningside and Medical campus are connected with an intercampus shuttle. The structure function imaging laboratory consists of wet lab space, fume hood, optical tables, and optical instruments needed to carry out the aims of this project.

All instruments are equipped with computers for data acquisition and processing. Software programs for data acquisition (LabView, CUDA), analysis (Matlab), optical prototyping (Zemax, CODEV), statistical analysis (Prism) are available to researchers. The laboratory has eight computers and an additional seven-office computers/laptops and electronic access to journals is available through the Columbia library. Each computer is equipped with an external hard drive for automatic back-up, and the laboratory maintains two RAID 20 terabyte servers to maintain copies of all experimental data. All investigators within Dr. Hendon's laboratory are members of a shared high performance computing cluster, Yeti.

Office

Dr. Hendon occupies a 200 sq ft office and graduate students share an office of approximately 400 sq ft. All office spaces are equipped with phone and high-speed internet capabilities.

Institutional Research and Facilities

Dr. Hendon will have access to the following resources located in the School of Engineering and Applied Sciences as well on the Columbia Medical campus.

- The Electrical Engineering Department has seven full-time administrative staff members that handle purchasing, grants and program management issues.
- *Machine shop*: Dr. Hendon and her group have access to a small machine shop that can be used for prototyping mechanical components within the engineering campus. Major equipment includes an end mill, lathe, band saw and grinding/sanding wheels for simple prototyping staffed with experienced machinists.
- Design and Biostatistics Resource (DBR). The Irving Institute for Clinical and Translational provides free consultations in biostatistics to aid investigators in grant proposals and analysis of data for manuscripts.
- Environmental Health and Safety. All researchers receive mandatory safety training each year in Laboratory Safety and chemical safety, biological safety and bloodborne pathogens, laser safety, and formaldehyde training.

Equipment

Dr. Hendon's Structure Function Imaging Laboratory at Columbia University in the Department of Electrical Engineering is located at the CEPSR Shapiro building on the 8th floor and has a total area of 600 sq ft.

Current Equipment within the Structure-Function Laboratory:

Optical Coherence Tomography Systems:

- Custom high resolution and high speed spectral domain OCT with Wasatch Photonics Cobra-S 800 OCT Spectrometer with InPhenix IPSDD0805C superluminescent diode light source centered at 870nm with 60nm bandwidth. The computer is a Dell Precision Tower 5810 using a National Instruments PCIe-1433 data acquisition card. [current location, Columbia University Irving Medical Center, Pathology]
- The laboratory is equipped with a Thorlabs Telesto I spectral domain optical coherence tomography system at 1300nm, with two interchangeable objective lenses and housings for the objectives to image samples while fully submerged in a solution.
- High-speed, custom built swept source at 1300nm, with 200kHz A-line rate (NTT-AT) and MEMS-based (HSL-20-100-M-3-S, Santec, Japan) swept sources, integrated Mach Zehnder interferometer (INT-MZI-1300, Thorlabs, USA) The system uses two dedicated data acquisition boards (ATS 9373, AlazarTech, Canada) for simultaneous recording of the OCT channel and phase-stabilizing calibration signal.
- An ultrahigh resolution spectral domain OCT system at 840nm, with a NKT SuperK EXTREME supercontinuum light source (Denmark), custom spectrometer with 2048-pixel CCD linescan camera (e2v, AVIIVA-II EM4 BA9, 12-bit), CameraLink framegrabber (NI, PCIe-1433), data-acquisition (DAQ) device (NI, PCI-6221). Ultrahigh resolution system can also be converted into a cross-polarized OCT system.
- Deep learning. Devoted computer for running deep learning experiments performed on a Dell Precision 7820 Tower with Intel Xeon Silver 4110 2.1GHz, and a NVIDIA® Quadro® P1000 GPU running Ubuntu Linux.
- A laptop-based, custom spectral domain OCT system has been developed which is comprised of a laptop computer (Lenovo Z50-70), 1300nm superluminescent diode (IPSDD1203-3113 InPhenix, Inc.), a spectrometer (Cobra 1300, Wasatch Photonics, Inc.), and a camera-link to USB3 converter (CL-U3, Pleora Technologies, Inc.). This system is housed in a custom enclosure (Protocase, Inc.) and is compatible with our custom-built OCT-integrated radiofrequency ablation catheters.

The laboratory also has two vibration isolated optical tables, oscilloscopes, broadband light sources, beam analyzer, an electronics workbench for circuit fabrication, fiber splicers, fibers and fiber probes with ball lenses and GRIN lens, which will be used for catheter fabrication. A temperature controller is available to image samples while submerged in a physiological solution in a bath or heated within a petri dish (TC-423C, Warner Instruments, Holliston, MA), where the temperature of the solution is maintained.

Near Infrared Spectroscopy Systems.

The laboratory has a custom near infrared spectroscopy system including four spectrometers (2 Thorlabs CCS175, Hamamatsu C9405CB, Mightex HRS-NIR-200) that spans the visible to near infrared, two broadband LED light sources (Thorlabs), halogen light source, and a range of multimode fiber probes. Two 4x1 fiber switches (LEONI Fiber Optics, Inc.) are available, to record spectra from catheters with multiple detection fibers. The system has been integrated into a compact 19inch rack mountable drawer to facilitate in vivo experiments. Custom design software has been developed for data acquisition and processing. The laboratory has numerous integrated NIRS and RFA catheters, where the tip used for integration are built at the Columbia University Machine Shop.

A custom computer has been built with an Intel Core i7-8700K 4.7GHz processor, 1TB SSD (Sandisk SSD Plus), and 2 graphics cards (NVIDIA Geforce 1050Ti & Geforce Titan Xp) for training deep learning models and running Monte Carlo simulations in reference to NIRS catheter development.

The endoscopic system for NIRS consists of a CMOS camera (Hamamatsu Flash4.0LT, Hamamatsu City, Japan), flexible fiber endoscope (Myriad Fiber Imaging Tech Inc, Dudley, Massachusetts) with 10,000 fibers, five collimated high-power LEDs (Thorlabs, M450LP1, M530L3, M625L3, M810L3, M940L3)

Pathology grossing station:

This dedicated space is equipped with a pathology grossing station and personal protective equipment, such as gloves, safety glasses, masks and face shields, are readily available to all researchers to enable working with human tissue. The wet laboratory space includes a dissection bench, fume hood, refrigerator, ice maker, sink, DI water, gross photography station, dissection microscope and supplies. This area will be used to document specimens and process tissue prior to histology.

Radiofrequency Ablation System.

A Biosense Webster radiofrequency ablation generator (Stockert 70) and flow pump (CoolFlow Pump), clinical catheters and return electrodes (3M Electrosurgical Pads) are available for conducting RFA experiments. Perfusion pumps (PeriStar Pro) and circulating water baths (Juloba) are also available to maintain physiological conditions during experiments. A custom tissue bath has been developed for conducting *ex vivo* experiments with flow.

Dr. Kam's Laboratory Facilities

Microscale Biocomplexity Laboratory

This 850 sq. ft space, centrally located in relation to the other DBME labs, includes tissue culture, microscopy, and molecular/cellular biology equipment. Additional facilities for electrospinning, electron microscopy, and material analysis are available in the same building, Engineering Terrace. Together with the clean room facilities described below, these resources provide all of the capabilities needed for the proposed project. Specifically, microscopy resources include live-cell imaging (Olympus IX71 and IX81 platforms) outfitted with EMCCD and sCMOS cameras and optics to provide high-sensitivity and high-resolution microscopy in a variety of modes, including epi- and TIRF-illuminated fluorescence. Confocal microscopy is also available to the Kam group through the Department of Biomedical Engineering. The cell biology and tissue culture facilities in the Microscale Biocomplexity Laboratory provide Biosafety Level 2 capabilities required for working with human blood products. Molecular biology capabilities include design, production, and transfection of DNA and RNA constructs into living cells, and have been demonstrated on a wide variety of T cells including primary mouse and human preparations.

Columbia University, Nanofabrication Clean Room Facility

The Nanofabrication Clean Room is a 5,000-sq. ft. facility in the Morris A. Schapiro Center for Engineering and Physical Science Research (CEPSR), on the Columbia University campus. This facility provides processing tools, instrumentation, and technical expertise required for the proposed project. This includes electron-beam lithography and thin film deposition equipment. These facilities are fully available for the proposed studies, and are supported by user fees.

CUNY Advanced Science Research Center

This building, located half a mile from the Columbia University main campus, offers a range of micro/nano-fabrication and imaging capabilities. Microscopy capabilities include two Bruker AFM platforms, a range of electron microscopes, and a Leica SP8 3X STED. These facilities are fully available for the proposed studies through user fees.

Herbert Irving Comprehensive Cancer Center (HICCC), Columbia University Irving Medical Center

Additional imaging and flow cytometry resources are available through core facilities within the HICCC. This includes STORM, PALM, and SIM superresolution imaging and multicolor flow cytometry and cell sorting. Dr. Kam is a member of the HICCC program, providing access to these facilities through user fees.

Animal

Department of Biological Sciences, Columbia University Morningside Campus:

Facilities include conventional rat (11th floor, 200 sq. ft) and mouse (6th floor, 600 sq. ft) housing, and a barrier room (5th floor, 500 sq. ft). This building is connected to Engineering Terrace, where the Kam laboratory is situated. This facility is supported by user fees, and is available for the proposed project.

Computer & Office

Dr. Kam has an office in the Engineering Terrace building on the same floor as his laboratory. His office and laboratory are equipped with computers for data collection, analysis, processing, and presentation that are sufficient for the proposed study.

Other

The Department of Biomedical Engineering at Columbia University offers several shared resources that will be critical to the proposed studies:

- 400 sq. ft. Machine shop suited for fabrication of mid-scale parts, such as those incorporated into microscopy stages and environmental chambers.
- Leica TCS SP8 confocal microscope, supported by user fees.
- Transfection/nucleofection platforms: AMAXA (Lonza) and Neon (Invitrogen) systems.
- Scanning electron microscopes

Equipment

The following list describes the most important equipment items needed for the proposed study. These are all available for the proposed project, and housed within the spaces described in the Facilities and Resources section.

Cellular and Molecular biology: The Kam laboratory is equipped to perform all of the cell culture and analysis techniques required for the proposed studies. This includes isolation and handling of cells of human or mouse origin, counting of cells for analysis of cell proliferation. Molecular biology capabilities of this laboratory include DNA and RNA vector design, production, and transfection, along with standard tools such as protein labeling and purification.

Microscopy: The Kam laboratory is equipped with Olympus IX71 and IX81 inverted microscopes, targeted for high-sensitivity and high-resolution fluorescence microscopy, as well as live imaging. Confocal microscopes capable of live cell imaging are also available for this project within the Department of Biomedical Engineering. Additional core facilities providing Atomic Force Microscopy (AFM) and superresolution imaging (STED, PALM, and STORM) are available for the proposed studies at the CUNY Advanced Science Research Center and the HICCC.

Flow cytometry: The Herbert Irving Comprehensive Cancer Center (HICCC) supports and manages core facilities that will be available for the proposed studies. In particular, flow cytometry and cell sorting facilities provide up to 18-color flow cytometry. In addition, the Columbia Center for Translational Immunology offers CyTOF mass cytometry,

providing detailed analysis of complex mixtures. These facilities are located on the Columbia University campus.

Fabrication: Photolithography, electron beam lithography, and thin-film deposition equipment available in the CEPSR and CUNY ASRC clean rooms are sufficient for carrying out the substrate microfabrication steps required for the proposed studies. In addition the Department of Biomedical Engineering provides 3D printing and machining capabilities that are needed for the proposed studies. These resources are made available through user fees, for which we are requesting support.

Sulzberger Columbia Genome Center: A core goal of the proposed studies is to link cell behavior with single cell transcriptome analysis. The sequencing capabilities provided by this core facility are available to and essential for the proposed studies.

Dr. Konofagou's Laboratory Facilities

Dr. Konofagou's laboratory facilities are located on the Health Sciences campus of Columbia University, in the Physicians and Surgeons Building, 19th floor (P&S 19), in the Columbia University Medical Center (CUIMC) occupying approximately 2000 sq.ft with additional space in the Vanderbilt Clinic, 12th floor (VC-12), in the Columbia University Medical Center (CUIMC) occupying approximately 950 sq.ft. Konofagou's laboratory is equipped with a computerized beam plotting device, different calibrated hydrophones, amplifiers, oscilloscopes, spectrum analyzer and vector impedance meters. A computerized high-resolution transducer positioning device with integrated computerized activation equipment is available.

Animal

The facilities available to Dr. Konofagou and to this project at Columbia University are excellent for the boarding animals prior to the experiments. Her VC-12 lab maintains facilities for performing sterile vascular surgery for mice, dogs and pigs as well as boarding of these animals for extended periods of time. The staff veterinarian examines these animals daily to assist with management. When not imaged, all animals will be housed in Columbia University's Institute of Comparative Medicine (ICM) facility on the 18th floor of the Black building, one floor below the PI's lab.

Computer

The ultrasound laboratory has several high-end Dell PC's for image analysis, signal processing and numeric finite-element simulation studies. All of these computers and the transducer calibration system computers are networked to the hospital network.

Office

Dr. Konofagou's office is located at the Physicians and Surgeons building at CUIMC which is approximately a 2 min walk from the VC-12 laboratory.

Other

The laboratory has a machine shop and electronics shop available. The electronic shop contains a considerable variety of electronic components and test equipment used to not only troubleshoot and repair components, but also to build customized equipment as needed. Columbia University Irving Medical Center Opened in 1928, CUIMC is staffed by more than 1,100 attending physicians, 400 residents, and 100 visiting fellows. Each year, the Center admits 42,000 inpatients and handles close to 700,000 visits to its outpatient clinics, doctors' offices, and emergency room. The Hospital also functions as a community hospital for the northern end of Manhattan, which provides a population base for clinical studies. The College

of Physicians and Surgeons of Columbia University is physically integrated with the Hospital, which allows close interaction between biological scientists of all types. The Columbia University Health Sciences Library includes a full microcomputer laboratory. A wide range of software applications, as well as instruction and computer workshops for beginners to advanced users, are available. The library offers students and researchers access to Medline, the leading bibliographic database of medical information from the National Library of Medicine.

Equipment

The following equipment items are located in Dr. Konofagou's laboratory:

- Theoretical finite-element software Abaqus, Algor, Comsol Multiphysics, LSDyna, GraphPad Prism, Labchart,
- Agar gel manufacturing materials and equipment including balance and stirring plates.
- Ultrasound transducers focused/linear: Sonic concepts H108 (2), H-204 (2), H215 (1), H (1) ADP-101, L7-4 (2), L22-14v (5), P4-1(1), P12-5 (2).
- Terason 2000 portable ultrasound system capable RF data acquisition at low frame rate
- Tektronix TDS5054B oscilloscope (Tektronix, Inc.)
- Amplifiers: Two ENI 325LA 50-dB amplifier; two E&I A150 amplifiers; 1 E&I 350L amplifier.
- 3 Customized degassing system; 3 Sonic Concepts WDS degassing systems
- Microgram balance systems
- 1- Two-channel, 160 MS/s, 14-bit Waveform digitizer for Peripheral Component Interface (PCI) Bus (CompuScope 14200, Gage Applied Technologies, Inc.)
- 4 - Four-channel, 120 MS/s, 14-bit Waveform digitizer for Peripheral Component Interface (PCI) Bus (CompuScope 14200, Gage Applied Technologies, Inc.)
- Thermocouples and thermocouple readers
- Three hydrophones (one needle, one bullet, one fiber-optic)
- Signal and image processing toolbox in Matlab
- 30 high-end Dell PC's for efficient signal/image processing studies in 2D and 3D
- GE Vivid 5 ultrasound system
- Ultrasonix Sonix RP with two phased arrays and a curvilinear array
- Ultrasonix Sonix MDP with two phased arrays and a curvilinear array
- Visualsonics Vevo 770 system with three probes at 30, 35 and 50 MHz (shared with Department of Medicine)
- Four Verasonics systems, one V1 with 64 channels; a second V1 with 128 channels mostly dedicated to other projects running in parallel; two standard frequency and 2 HIFU Vantage systems with 256 channels are also available.
- Two AD Industries pressure catheters
- One Shelley Compuflow programmable vascular pump
- Zeiss OPMI-1B surgical microscope
- Sonomicrometry system (Sonometrics, Inc.)
- St. Jude Medical EnSite™ Velocity™ Cardiac Mapping system
- Ablation catheters, TactiCath, St. Jude Medical, Secaucus, NJ
- ViewFlex PLUS ICE catheter, St. Jude Medical, St. Paul, MN
- Ensite Electroanatomical Mapping and RF ablation system, St. Jude Medical, St. Paul, MN
- Two Kinova Robotics JACO 4 DOF robotic arms.
- Leica Impact One™ Stereotaxic Impactor for CCI
- Leica DM6 microscope
- Three Biopac modular DAQ systems (ECG, SPO2)

The following equipment are shared in the department of Biomedical Engineering:

- Bruker 400 MHz (9.4 T) NMR Microimaging System equipped with microimaging capability
- Flow Cytometry with a BD Biosciences FACS Aria system with 3 lasers
- Olympus Fluoview IX70 Confocal Microscope equipped with argon and krypton lasers capable of three excitation wavelengths of 488, 568, and 647 nm (imaging software: Fluoview 2.1).
- Atomic Force Microscopy BioScope Catalyst (Bruker, Billerica, MA).
- Instron Microtester (Instron, Inc., Norwood, MA)
- ARES rheometer (TA-instruments, New Castle, DE)

Other Resources

Department of Radiology Imaging Infrastructure and Clinical Facilities

The Department of Radiology has 7 clinical divisions 1) Abdomen and Chest 2) Interventional Radiology 3) Nuclear medicine 4) Musculoskeletal 5) Pediatrics 6) Breast Imaging and 7) Medical Physics. The clinical imaging facility include the CUIMC/NYP main campus which houses the NYP Columbia Hospitals, Columbia radiology neurological institute MR center and the David Gardner PET center (10 MRI scanners, 10 CT scanners, 11 special procedure rooms, 3 PET/CT scanners, 2 SPECT/CT, 25 fixed R/F units, 10 digital mammography units, and a large number of mobile radiographic units, mobiles fluoroscopy units, and ultrasound units), NYPH has a fully integrated PACS system running on a medical grade network. In addition the department of radiology has a cutting edge post-processing 3D lab providing the latest advanced quantitative and qualitative imaging. This advanced 3D lab named center for advanced image processing and analysis (CAIPA) optimizes the radiologist workflow and reading times by providing routine post processing for all clinical care.

Columbia Radiology MRI Center

The lower level of the Neurological Institute Building on the Columbia-Presbyterian Campus houses the Columbia Radiology MRI Center. This facility currently includes three MRI scanners with hardware and software for BOLD MRI, cardiac, proton spectroscopy, enhanced DWI, and DTI. It is also equipped to synchronize visual stimulus with either a rear projection screen or visual goggles, eye-tracking data, audio stimulus and physiological data acquisition (EKG, peripheral pulse, respiration, skin conductance), and there are multiple subject response systems; button response, trackball, and joystick. All 3 scanners have capability of running research MR pulse sequences. In addition, for pulse sequence development there is access to vendor MR pulse programming environment installed on workstations in medical physics lab space. All 3 scanners have been set up to use multiple software's; E-Prime, Presentation, Matlab, and can integrate any other software brought in by the principal investigators.

The Laboratory for Computational Image Analysis at CUIMC

The Computational Image analysis lab in the Department of Radiology at Columbia University Medical Center has about 900 square feet. It is located on the Health Sciences Campus (Radiology) in the Neurological Institute Building and equipped with a dedicated hospital PACS (GE Centricity), a research PACS server and 10 high-end PCs (Intel Xeon X5550 Quad Core @ 2.67GHz or Intel Xeon E5-2620 Six Core @2.0G Hz, 8G Memory, 10TB Storage capacity for the server and 2TB for the PC workstations), and a Sun Ultra 5/10 workstation. All PCs are equipped with 19" dual monitors or 23" wide screen monitors. Network connectivity is via the hospital's 100MB Ethernet. Clinically acquired DICOM images can be pushed from the hospital PACS to the research PACS server through the hospital network. A database has been created to capture clinically relevant data elements linked to the image sets. DICOM images are stored in the research server with the patient identification information removed. Several commercial software packages (e.g., IDL, Matlab) and "home-grown" image processing software and image visualization tools are available for different research projects. A Weasis

based viewing application has been developed that allows for incorporation of customized algorithms for rapid prototyping and testing by programmers and clinicians. In addition, this viewing system has all the basic visualization functions and manual editing tools. We are using GE Centricity software and our own customizable software to remove protected health information (PHI) from DICOM images before exchanging patient image data with other cancer centers, institutions and universities.

Clinical Facilities:

In 2020, the Department of Radiology performed over 500,000 imaging procedures and is one of the busiest research centers in the world. These numbers include NYP Columbia, NY Children's Hospital, NYP Allen Hospital and offsite Columbia Doctors Radiology satellite location. The Department of Radiology offers a residency program in Radiology. The department has well-qualified and experienced specialty boarded faculty members, and an established clinical research environment that manages all aspects of protocol submission, compliance, and trial support. The Department also has a CAMPEP imaging medical physics residency program with currently 2 residents in the program. Currently, there are 70 faculty members on staff in the department of radiology, 15 fellows, 32 radiology residents and 2 imaging physics residents. Residents are involved in clinical training and research with radiology faculty.

The Department of Radiology has 7 clinical divisions 1) Abdomen and Chest 2) Interventional Radiology 3) Nuclear medicine 4) Musculoskeletal 5) Pediatrics 6) Breast Imaging and 7) Medical Physics. CCTA, SPECT, ICA and echocardiography systems are constantly updated and upgraded. ICA is performed with 3 different types of Fluoro machines (Philips, GE).

The clinical imaging facility include the CUIMC/NYP main campus which houses the NYP Columbia Hospitals, Columbia radiology neurological institute MR center and the David Gardner PET center (10 MRI scanners, 10 CT scanners, 11 special procedure rooms, 3 PET/CT scanners, 2 SPECT/CT, 25 fixed R/F units, 10 digital mammography units, and a large number of mobile radiographic units, mobiles fluoroscopy units, and ultrasound units), NYPH has a fully integrated PACS system running on a medical grade network. In addition the department of radiology has a cutting edge post-processing 3D lab providing the latest advanced quantitative and qualitative imaging. This advanced 3D lab named center for advanced image processing and analysis (CAIPA) optimizes the radiologist workflow and reading times by providing routine post processing for all clinical care.

Dr. Kyle's Laboratory Facilities

Dr. Kyle's activities primarily take place in the Department of Biomedical Engineering (DBME) at Columbia University's Morningside Campus. DBME is housed in the Seeley R. Mudd Building, located on the north side of campus in West Harlem. The Department is a well-equipped space for student instruction, with following spaces available to support the design education efforts of the Hk Maker Lab:

- Teaching Lab: 962 ft² 3 Benches, 8 workspaces, 4 students/workspace
- Design Lab: 523 ft² 3 Work Benches, Dell PCs (6)
- Laser cutter, benchtop machining devices, 3-D printer (4), circuit board printer
- Multi-purpose Room: 588 ft² flexible workspace devoted to interactive teaching
- 8 Dell PCs with appropriate software, e.g., MS Office, SolidWorks, MATLAB
- Machine Shop: 487 ft² equipped with tools to create advanced Design prototypes

Dr. Kyle's office is located in 363 Engineering Terrace, on the same floor as the Undergraduate Laboratory.

Researchers also have access to the common areas and teaching spaces in the Mudd building. Some spaces of interest include:

- MakerSpace: University-run workshop with a wide variety of fabrication tools including 3-D printers, laser cutter, machine shop, water jet cutter, electronics, vinyl cutter, and woodworking tools
- Computer Labs: Teaching labs equipped with 60 computers and requisite software CAD, microcontroller programming, and simulation
- Carleton Commons: Open congregation space that can accommodate 250 people
- Davis Auditorium: 185 seat amphitheater with A/V capacity

Dr. Leong's Laboratory Facilities

Dr. Leong's Laboratory Facilities has 2,000 sq. ft. of laboratory, bench, and office space on the 4th Floor of the Mary Woodward Lasker Building in the Columbia University Medical Center.

Available in Leong's laboratory at Columbia University are facilities for polymer synthesis, radiochemical synthesis, polymer characterization, DNA measurement, gel electrophoresis, static cell culture, bioreactor cell culture, PCR and real time PCR, molecular biology assays, particle size and surface charge measurement, mechanical and rheological characterization, gel plates, optical analysis, and drug release kinetic studies. Custom-built instruments for this project are two microfluidic stations equipped with either high speed cameras or fluorescence microscopy.

Animal housing and surgical facilities for both small and large animals are provided in the Columbia University School of Medicine. Staff include veterinarians, administrative and secretarial staff, and animal caretakers. Surgical supervision and consultation regarding histopathological processing and evaluation are available.

Equipments available to research, either in the lab or in Central Facilities of the Morningside campus or the Medical Center include HPLC System, Hewlett-Packard 1090M; NMR (FT-NMR, C-13, P-31) (Chemistry); Micro/nanofabrication facilities (School of Engineering and Applied Sciences, Columbia); UV Spectrophotometer, Shimadzu; Differential scanning calorimeter; Malvern Zetasizer; Chemical hoods; Biological hoods; Computer Image System; Incubators; AFM, ESCA (Materials Sci. Dept.); scintillation counter; ultracentrifuges; SEM and Confocal Microscopy (Cancer Center); Electron microscopy (Stem Cell Core); Cell Analysis-96 system; Laboratory Automation Workstation; ELISA Microplate Reader, Nanodrop, Super-resolution microscopy.

Dr. Lu's Laboratory Facilities

The Biomaterials and Interface Tissue Engineering Laboratory occupies 850 sq ft and is located in Engineering Terrace, Room 364, FF-SEAS. Research focuses on musculoskeletal interface tissue engineering and the development of novel biomaterials and scaffolds. The space is divided into four working areas: scaffold fabrication, biomaterial characterization, *in vitro* culturing, and biochemical analyses. The laboratory is also fully equipped to perform biochemical and molecular assays relevant for this proposal.

Animal

Columbia's IACUC (Institutional Animal Care and Use Facilities) maintains a fully accredited animal facility that includes a staff of veterinary ancillary services, and three licensed veterinarians who oversee the care and use of all animals, to ensure personnel are properly trained in animal-related procedures, and to provide advice/assistance when needed. The animals are housed in the IACUC facilities and are cared for on a daily basis by this veterinary staff.

Computer

The laboratory is equipped with zoom and video conferencing capabilities, one HP LaserJet 2200dn printer, Epson Perfection 2400 Color flatbed scanner, and five Dell Dimension XPS systems: one for the Tecan Spectrafluor Plus system, one for the FTIR system, one for the microscope, and two others for data processing

Office

The office is equipped with a personal computer, printer, telephone, and other standard office equipment, along with fax, photocopy, and conference room in the office suite in Room 351 of Engineering Terrace.

Equipment

The Laboratory currently houses equipment for biomaterial synthesis/scaffold fabrication (Hitachi Programmable oven, Retsch Analytical Sieve Shaker, Spellman High Voltage Power Supply), and surface characterization equipment such as a DigiLab Fourier Transform Infrared Spectroscopy (FTIR) system as well as a state-of-the-art Perkin Elmer FTIR-imaging system. Two custom-designed electrospinning systems are available for nanofiber fabrication, coupled with multi-jet ejection systems for both multiple fiber type and/or cell electrospinning. In addition, a Tecan Spectrofluor PLUS microplate reader can be used to quantify absorbance, fluorescence and luminescence, and a Bio-Rad iCycler thermocycler with BioRad iCycler optical system can be used for Real Time PCR analysis. A Zeiss Axiovert 25 C cell culture microscope, and Zeiss Axiovert 25 CFL fluorescent microscope equipped with a digital image acquisition system are located in the cell culturing module of the laboratory. The laboratory also has a gel electrophoresis system, homogenizer, table-top centrifuge, refrigerated IEC Micromax microcentrifuge, histological staining equipment, multi-action rotator/rocker, Centrivap, and dry-bath.

Other Resources

BME Freezer Room (Room 371 Engineering Terrace), is a renovated 150 sq ft room housing a -80°C freezer, a double door -20°C freezer, a double-door refrigerator, ice machine, and chemical hood. In addition, stainless steel tables for specimen preparation and tissue dissection are available, and this room also houses a freezing stage microtome, lyophilizer and assorted needs for histological preparation and staining.

BME Histology Core Facility (Room 370 Engineering Terrace), is designed for the processing of hard and soft tissues for routine histological analysis. The facility provides equipment for complete tissue processing as well as a paraffin-embedding station and a Leica 2030 rotary microtome for tissue sectioning. In addition, a slide staining setup is available for tissue characterization with a variety of histological stains including Hematoxylin and Eosin, Masson's Trichrome, Von Kossa, Alcian Blue, and Safranin O. Immunohistochemical staining equipment is also available as are several microscopes for slide viewing including an Olympus BX60 optical microscope and an Olympus IX70 inverted microscope with a confocal laser scanning attachment.

BME Confocal Microscope Facility (Room 389 Engineering Terrace) - This departmental facility houses an Olympus Fluoview confocal laser scanning microscopy system which will be

used for the outlined studies. The system includes an Olympus IX-70 inverted microscope, heating stage, DIC optics, various high NA objectives, transmitted light detector, mercury, argon and krypton lasers, Fluoview software and workstation. There is also a general purpose Olympus CK40 inverted microscope with a Sony 3 color chip camera and high resolution monitor using a PC driven by Metalmaging software (UIC). Other equipment include a uv-vis spectrophotometer, freezing point osmometer, glass viscometers, centrifuge, water bath, pH meter, conductivity meter.

Scanning Electron Microscope - Within the Fu Foundation School of Engineering and Applied Science at Columbia University, the Materials Research Science and Engineering Center (MRSEC), supported by the NSF, operates and maintains a series of shared experimental facilities including a JEOL JSM-5600LV scanning electron microscope (SEM) equipped with an X-ray analyzer for Energy Dispersive X-ray Analysis (EDXA). The system is located in Room 1112 of the Mudd Building, which is attached to Engineering Terrace where the Biomaterials and Interface Tissue Engineering Laboratory is located.

The Machine Shops at the Department of Mechanical Engineering and the Dental School of Columbia University will provide machining for custom molds for the scaffolds. The PI also has access to the BME Cell Culture Core Facility, BME Freezer Room, BME Histology Core Facility, BME Confocal Microscope Facility, Scanning Electron Microscope, Mechanical Testing Systems (Shear, Tensile and Compression), BME Machine Shops, as well as Biological Sciences and Chemical Engineering Facilities [Differential Scanning Calorimetry, Gel Permeation Chromatography (GPC), High Performance Liquid Chromatography (HPLC), and Mercury Porosimetry].

Dr. Myers's Laboratory Facilities

Dr. Myer's laboratory facilities are located on the campus of the Columbia University Irving Medical Center (CUIMC) in the Mary Woodard Lasker Biomedical Research Building (Lasker), 3960 Broadway, Room 450D-E, New York, NY 10032, in space that is part of Columbia University's Fu Foundation School of Engineering and Applied Science (SEAS).

Myers Soft Tissue Lab Equipment (Director – KM Myers, Ph.D., Room Lasker 450DE: 1100 square feet of wet lab): The Myers engineering lab, which specializes in the characterization of reproductive tissues, contains several custom-designed devices for testing the multi-axial biomechanical properties of soft biological tissues and -biomaterials. Tissue testing modalities include tension, compression, microindentation, bulge inflation, swelling, and the assessment of hydraulic permeability. Our material testing equipment includes 2 Instron 5948 Microtesters equipped with 5, 10 and 50 Newton load cells (Instron Inc., Norwood MA), custom-built environmental fluid chambers and a Piuma nanoindenter (Optics 11 Life, Amsterdam, NL) with a dynamic viscoelastic testing modes at the nano- and microscales. To measure multi-axis 3-dimensional tissue deformation we have a 3-D Digital Image Correlation (DIC) Video Extensometer System (Correlated Solutions Inc., Columbia, SC). The 3-D DIC system is equipped with 8 separate CCD cameras (4 – Pt. Grey Research GRAS-50S5M-C & 4 – FLIR Grasshopper3 5MP) with 75mm lens (Pentax CCTV lens 75mm F/2.8, model: C35700KP), along with custom rigs outfitted with optical tools (e.g. right-angle prisms) to capture deformation at various angles.

This lab also houses equipment for the biochemical analysis of biological soft tissues: Mettler-Toldeo Micro balance (MS105), Labconoco freeze drier (FreeZone4.5), microcentrifuge (Beckman Coulter, Microfuge 16), PicoTag Work Station (Waters Millipore), spectrophotometer microplate-reader (BioTek, Epoch), custom dissection tools and blades, custom tissue pulverizer, temperature block, an Olympus SZ61 stereo microscope, sledge

freezing microtome (Leica SM2010 R), negative 20°C freezer (VWR, FSF-2020), negative 80°C freezer (Thermo Scientific Revco RLE Series), and 4°C refrigerator. Other ancillary equipment for preparing testing solutions and test specimens, as well as multimeters and other electronic equipment are available. Two digital SLR cameras (Canon Rebel T1i) are also available that can be mounted on the stereoscope.

Tissue culture laboratory equipment for the purpose of maintaining mammalian cells and tissues *in vitro* is also possessed by the lab. This includes a Class II Biosafety Cabinet, Type A2 (NU-543-500, NuAire Inc., Plymouth, MN), incubator, water bath, and Leica DMI1 inverted microscope outfitted with a camera and four objectives.

To facilitate clinical studies in pregnancy, our lab also owns two cervical aspiration devices (Pregnonia AG, Zurich) to measure *in vivo* cervical stiffness. We also access the use of a quantitative Rapid fetal fibronectin test on the PeriLynx System (Hologic, Inc., USA).

Myers Soft Tissue Computational Resources

Columbia University Information Technology centrally-managed High Performance Computing Cluster, Ginsburg: This high performance computing facility consists of 139 nodes with a total of 4448 cores (32 cores per node). All servers are equipped with Dual Intel Xeon Gold 6226R processors (2.9 GHz). The Myers lab owns 1 node of the Ginsberg cluster.

Backup External Drives: (4) Seagate 2 TB USB 3.0, (6) Seagate 4TB USB 3.0, (1) My Passport WD 4TB external drive, (1) LaCie 1TB Mobile SSD (1) Synology DiskStation Network Attached Storage (DS1815+) with 30 TB of RAID backup drives (21.7 TB usable backup space)

Desktop Computers: (1) Lenovo Core i7 3.4GHz, 32GB RAM, 1TB hard drive, (1) Lenovo Core i5 3.1 GHz, 4 GB ram, 450GB hard drive, (1) Core i7 3.1 GHz, 6 GB ram, 1TB hard drive, (1) Core i7 3.4 GHz, 8 GB ram, 2 TB hard drive, Dell, i7 3.2GHz, 64GB ram, 4+1TB hard drive, (1) Lenovo, Xeon E3 3.4GHz, 32GB ram, 512GB hard drive SSD, (1) HP, Xeon 3GHz, 24 GB ram, 500 GB hard drive, (3) Dell, i7 3.6GHz, 64GB ram, 1TB hard drive, (1) Lenovo, Xeon 3.7GHz, 16GB ram, 475GB hard drive, (1) Apple iMac 3.4GHz Core i7, 32GB ram, 3TB hard drive, (1) Dell Precision 3540 Tower, i9, 3.7GHz, 64 GB ram, 2 TB hard drive, (1) Dell Precision 3640 Tower, i9, 3.7GHz, 64 GB ram, 2 TB hard drive

Myers Soft Tissue Lab Software: The analysis software includes both open-source and commercial codes. The finite element code is FeBio. We currently use Hypermesh (Altair, Troy, MI) for geometric meshing and we use Solidworks 2019 (Dassault Systems, Waltham, MA) for solid modeling. For digital image correlation we have Correlated Solutions Vic 3D software (Correlated Solutions Inc., Columbia, SC). Other available software includes: Matlab 2019a, Adobe Creative Cloud, and the Microsoft Office Suite.

The Myers Soft Tissue Lab Offices: The Myers lab has 6 graduate student desks in the shared office space located in 420A Lasker (780 sq. ft.), and 1 post-doctoral desk in the shared office space in 410 Lasker (222 sq. ft.). The wet lab also has bench space for up to 6 undergraduate students, masters students, and/or lab visitors. Dr. Myers occupies additional offices (200 sq. ft.) in 234 S.W. Mudd on the Morningside Heights campus of Columbia University (500 W. 120th St., New York, NY 10025) and 420C Lasker (100 sq. ft.) on the CUIMC campus.

Clinical (Also resources for Drs. Vink and Wapner)

Columbia University Irving Medical Center (CUIMC) Situated on a 20-acre campus in Northern Manhattan and accounting for roughly half of Columbia University's nearly \$3 billion annual budget, Columbia University Irving Medical Center (CUIMC) provides global leadership in scientific research, health and medical education, and patient care. CUIMC

consistently has been praised for the quality, innovation, and academic rigor of its educational programs and for the unsurpassed excellence of its faculty. Faculty members from its four schools carry out the school's core mission of educating and training future generations of health care professionals; conduct basic research with the ultimate goal of translating discoveries into new techniques for fighting disease and improving health; are responsible for a number of significant clinical breakthroughs.

Clinical and Translational Research in the Reproductive Sciences - CUIMC's Department of OB/GYN's Division of Research, which is led by Dr. Ronald Wapner, has one of the nation's best records in organizing and participating in clinical and translational research including multicenter trials. Our success is due to our preexisting integrated research infrastructure which is complemented by our diverse population of over 6,600 deliveries/year, elaborate system of prenatal clinics and obstetric services, advanced support systems, strong division of Neonatology, and outstanding follow-up programs and a patient population proven to be receptive to participation in research. The Dept. of OB/GYN, which is in the main clinical CUIMC building, also has a critical mass of full time academic faculty with sufficient time and skill to perform leading clinical and basic science research and a proven track record of advancing junior faculty to independent funding.

Other

Columbia University Department of Mechanical Engineering Machine Shop: (Room 279, Engineering Terrace, 2nd floor) This machine shop is located in the Department of Mechanical Engineering. It is equipped with three three-axis vertical milling machines, three lathes, a Fadal VMC 15 computerized numerical control (CNC) vertical machining center, a grinder, a Brown and Sharpe coordinate measuring machine (CMM), an FDM 2000 rapid prototyping machine, and various bandsaws and other machining tools.

Columbia University Department of Mechanical Engineering MechTech Laboratory: (Room 273, Engineering Terrace, 2nd floor) This department resource is equipped with: power supplies (for low-power electronics and higher-power control), function generator, multimeter, protoboard for building circuits, microcomputer circuit board (which includes the microcomputer and peripheral components), microcomputer programmer, personal computer that contains a data-acquisition board, portable oscilloscope, EPROM eraser (to erase microcomputer programs from the erasable chips), logic probe, analog filter bank

Columbia School of Engineering and Science Innovation Hub (Makerspace): (Room 245, Mudd Building, 2nd floor) This space consists of: 3D Printers (Ultimaker 2 Extended +, Ultimaker 3 Extended, Formlabs Form 2), laser cutter, VLS 3.50, computer numerically controlled lathe: HAAS ST-20Y, computer numerically controlled milling machine: HAAS Mini Mill

Columbia University Library electronic research notebook enterprise license, LabArchives: Cloud-based electronic notebook system to manage the results of research efforts, record and document research processes and procedures, and manage digital research data in ways that increase reproducibility, efficiency, collaboration, searchability, and security.

Dr. Pe'er's Laboratory Facilities

Dr. Pe'er's Laboratory Facilities is 500 sq. ft. of computer laboratory space at the Department of Computer Science including a private web server, a lab disk server and 9 workstations.

Office

Dr. Pe'er has office space of 167 sq. ft. and additional (non-lab) student office spaces of 170 sq ft. for the use of the current project

Computer

Dr. Pe'er is a member of the Center for Computational Biology and Bioinformatics (C2B2), and enjoys access to the state of the art data center to support biology related research computing at Columbia University as described below. C2B2 provides access to major databases and licenses of commonplace software packages in genetics and sequence mapping/assembly (see description by co PI)

As a member of the Computer Science department, Dr. Pe'er enjoys access to distributed storage of >200TB at the Moose-FS filesystem with automatic backup and recovery.

Equipment

Sun Fire disk server with 24TB hot-swappable space owned by the Pe'er lab, housed at and supported by the Computing Research Facility of the Department of Computer Science.

In addition, the PI enjoys access to the C2B2 data center: a 2000 ft.2 server room capable of housing up to 86 server racks, including 22 high-density racks (50 servers each) with a 1 MW UPS unit and a 10 Gbps core network infrastructure.

A high performance compute cluster of 466 systems (3728 processor cores) ranked #124 in the international Top500 Supercomputers list, recognizing it as one of the most powerful computers in the world.

An Isilon® clustered Network Attached Storage (NAS) solution provides a scalable, reliable, high-speed 168 TB of storage to the compute cluster to facilitate the manipulation of very large data sets.

The research computing environment is augmented with a high capacity, scalable backup infrastructure and a robust computing infrastructure offering database, web, mail/collaboration, and authentication services.

Dr. Purdie-Greenaway's Laboratory Facilities

The Laboratory for Intergroup Relations and the Social Mind Lab at Columbia University is the primary laboratory and workspace of the Dr. Purdie-Greenaway. The Lab is uniquely equipped to facilitate the proposed project.

The Department of Psychology provides office space, resources such as photocopiers and fax machines, and administrative support to proposed IMWEL personnel. The department has business offices staffed with experienced grant administrators. The department has a newly renovated conference room and other rooms are available for use.

Columbia University connects researchers with up-to-date and literature through its library facilities. The Department of Psychology provides a number of specific academic and administrative resources that makes the department particularly well-suited for the proposed project and the Purdie-Greenaway lab has the space and resources needed to collect, analyze, and disseminate data from the proposed studies.

The Purdie-Greenaway lab occupies a recently-renovated wing of the Psychology Department. It contains a separate facility for conducting experiments that includes a waiting

area, two smaller rooms for single-participant studies, and a large room for group studies with advanced video recording hardware. The lab also features a separate electronically-secured work space and meeting area for research staff and faculty. This workspace contains seven networked computer stations for data entry and analysis, as well as laser printers, scanners, and a telephone system. The workspace also includes two large conference tables and a large whiteboard that are used for regular project coordination and planning sessions and two separate offices for private meetings and video conferencing with remote collaborators. There is ample storage space, including locked file cabinets for securing hard copies of data files.

Computer

The lab faculty and staff use Dell systems with standard configurations, and Columbia University's Information Technology unit ensures that licensed software and up-to-date antivirus software are available.

Dr. Vunjak-Novakovic's Laboratory Facilities

Dr. Vunjak-Novakovic is on faculty at the Department of Biomedical Engineering (Morningside Campus), Department of Medicine and College of Dental Medicine (Medical Campus). She is also a faculty member of the Herbert Irving Comprehensive Cancer Center and the Center for Human Development. The core facilities and centers she is directing or co-directing provide substantial additional resources and expertise that will be fully utilized for the proposed project.

Dr. Vunjak-Novakovic is a founding member of the **Columbia Stem Cell Initiative (CSCI)** that provides a robust intellectual environment and access to major resources for interdisciplinary research. Collaborations between engineers, clinicians, and biologists are facilitated through a network of over 100 laboratories with sharing of expertise and resources. The CSCI also serves as a hub with surrounding organizations (including the Columbia University Medical School, Columbia Hospital System, New York Stem Cell Foundation, and other Universities in New York City). Her lab serves as the main bioengineering resource for the CSCI.

Dr. Vunjak-Novakovic is the PD/PI of the **Tissue Engineering Resource Center**, PI of the **Functional Imaging Core for Stem Cell Research** at Columbia Morningside, providing top of the line resources for live imaging, and the founding scientific director of the Columbia Stem Cell Core that provides significant resources for stem cell research.

Laboratory

Dr. Vunjak-Novakovic's **Laboratory for Stem Cells and Tissue Engineering** is a 3,000 sqft research facility (wet and dry space) fully equipped for stem cell and tissue engineering work, with a full time lab coordinator, program administrator, one research engineer, and four technical assistants.

The lab has two **separate cell culture rooms** dedicated for work with human stem cells (adult, embryonic and iPS), a "**Bioreactor shop**" for assembly and testing of bioreactors, a **dedicated imaging room**, and **biomechanical and electromechanical testing facilities**.

Adjacent laboratories are dedicated to:

1. **Biomaterials** - Preparation of hydrogels and scaffolds for stem cell research and tissue engineering (a separate lab adjacent to the main lab space)
2. **Analytics** - (RT-PCR, biochemistry, live-dead assays, medium composition, electromechanical measurements, mapping of electrical potentials),
3. **Animal surgery** - (VC12-233) fully equipped for small and large animal studies.

4. **Stem Cell Core** - (BB1109) with a Director (Dr. Barbara Corneo) and six dedicated technicians for standardized derivation and characterization of human stem cells, and their differentiated derivatives.
5. **Functional evaluation** - equipped for molecular and electrophysiological assays of stem cells.
6. **Imaging Core** - fully equipped for functional imaging of cells and tissues, and in vivo imaging in animal models
7. **Bioreactor “Shop”** – dedicated to the creation of novel bioreactors.

Animal

Columbia University is accredited by the American Association for Accreditation of Laboratory Animal Care and registered with the US Department of Agriculture. There is an Animal Welfare Assurance on file with the Office for Protection from Research Risks (Animal Welfare Assurance number A3415-01). The facilities are fully staffed with certified veterinarians and supporting staff, with veterinary support on a 24-hour basis, and daily inspection of all animals for signs of infection and distress. All investigators working on animal studies have been trained by the Columbia University Institute of Comparative Medicine, with mandatory renewal of each training and animal protocol.

Dr. Vunjak-Novakovic has a **dedicated and fully certified surgery room** equipped for small and large animal research, right adjacent to her lab (VC12-233) that she is sharing with another PI. The surgery room is equipped with surgery microscopes, anesthesia equipment, systems for lung perfusion and ventilation (ECMO), and all other equipment needed for animal research.

In addition, she has a **dedicated and fully certified surgery room for large animal (pig) studies** in the same building, that is equipped to the standards for human transplant surgeries, and supported by a veterinary team. This facility has been used for short and long term survival surgeries, cross-circulation support of animal and human organs and transplantation of bioengineered human organs.

Computer

Computer equipment includes dedicated computers for complex modeling work (COMSO FEMLAB, CAD), microscopes and other equipment (electrical stimulation, RT PCR), 28 office computers for students, fellows, lab coordinator and program administrator, and a personal computer exclusively for use by the PI. LabView, MatLab, Metamorph, software for automated microscopy, bioreactor control, image processing, and mechanical testing are installed as necessary on dedicated computers. Three laser printers, scanners, fax machines, and all computers (except for those dedicated to the control of instruments and experimental setups) are networked and have Internet access.

Office

Primary office for Dr. Vunjak-Novakovic and 6 offices for postdoctoral scientists and graduate students are located adjacent to the lab. Conference room with teleconferencing capability is also available. A secondary office for Dr. Vunjak-Novakovic is located on the Morningside Campus.

Shared Facilities

Data Science Institute / Computer Science Department

*Drs. Azizi, Hendon, Pe'er have access to the facilities at DSI.

The Data Science Institute has multifunctional shared spaces as well as state-of-the-art equipment, instrumentation, and computation and laboratory facilities that exist within the Data Science Institute, and other venues, like conference rooms and classrooms within Columbia University, that can be made available for the research, education and outreach initiatives outlined in the proposal. Note that all faculty researchers have access to work computers and office space.

The Data Science Institute is housed within 44,000 square feet of multifunctional space at Columbia University. This space includes faculty offices, conference rooms, student workstations and collaborative meeting spaces, all designed to promote a collegial and interactive physical community around data science and to encourage interdisciplinary approaches to research training. The Institute also has support staff to assist with the financial management of the project, as well as the educational and outreach activities associated with the project.

The Data Science Institute has access to Yeti, a High Performance Computing (HPC) Cluster housed in Columbia's centrally-managed Shared Research Computing Facility (SRCF), which consists of a dedicated portion of the university data center. The total server count is 167 execute servers with a total of 2762 compute cores. The CPU on all expansion machines is the 2.6 GHz E5-2650v2.

The Data Science Institute has also bought in two secure dedicated resources on the new Habañero cluster, which came online in November 2016. These resources consist of two "high memory nodes" and two "GPU nodes" along with 4TB of storage - whereas the overall specifications of the cluster are:

- 222 nodes with a total of 5328 cores (24 cores per node):
- 208 HP ProLiant XL170r Gen9 nodes w/dual Intel E5-2650v4 CPUs (2.2 GHz):
- 176 standard memory nodes (128 GB)
- 32 high memory nodes (512 GB)
- 14 HP DL380 Gen9 nodes with dual Intel E5-2650v4 Processors (2.2 GHz) and NVIDIA K80 GPU (2 per node) supplying ~140,000 GPU cores
- 407 TB DDN GS7K GPFS storage
- EDR Infiniband (FDR to storage)
- Red Hat Enterprise Linux 7
- Slurm job scheduler

Additionally, the Institute acquired from Yahoo! 40 HP compute servers to be used to support Institute research projects. These machines are configured with HP DL160 G5 2 x L5420 CPUs, 16GB of RAM and 1 x 1 TB 7.2K SATA Disk.

Shared storage is available through a Network Appliance storage file server.

The Computer Science departmental computing infrastructure consists of a data center for computational, storage and VoIP services, one large student laboratory, featuring 18 Windows machines and 33 Linux towers each with 2 Nehalem processors, 8 cores and 24GB memory; a remote Linux cluster with 17 servers each with 2 Xeon processors and 4GB memory, and a number of computing facilities for individual research labs. The data center houses 14TB of Network Appliance file servers, a compute cluster consisting of a Linux cloud with 32 servers

each with 2 Nehalem processors, 8 cores and 24GB memory. This cloud can support approximately 5000 of VMware instances. Additional computing facility includes 8 Intel Linux servers with 8 processors and 16GB memory each and 3 Sun Fire 280R servers, a 3Com VoIP system, and departmental load balanced web cluster with 6 servers and business process servers, an online backup server with 40TB capacity, along with supporting servers that provide print services, LDAP, DHCP, DNS, tapes backup and software distribution to the department. The data center is internally connected via Gigabit Ethernet and accesses the Internet and Internet2 via the campus fiber network. The University provides 802.11b coverage for most of the campus.

Columbia University Information Technology maintains Columbia's commodity Internet connections that include 1 Gb/s via Level 3, 5 Gb/s via Cogent and 100 Mb/s via RCN (for RCN residential cable modem customers). Columbia's research and education network connections include a NYSERNet NYC and statewide regional optical network ("dark fiber"), a 1 Gb/s connection to NYSERNet's IP network and from there to Internet2 and National Lambda Rail (NLR) packet net and 1 Gb/s connection to the US Large Hadron Collider Network (USLHCNET) providing connectivity to CERN.

The research infrastructure includes many Sun, Dell and HP servers and hundreds of workstations from Apple, Dell, HP and other PC manufacturers. The labs for research in image processing, vision, graphics, and robotics contain such specialized equipment as a Data Cube image processor, an Adept1 robot, and Aspex PIPE (an eight-stage parallel, pipelined, low-level image processor), Unimate Puma 500 and IBM robotic arms, a Utah-MIT dextrous hand, high performance 3-D graphics workstations, 3-D position/orientation trackers, see-through headworn displays, and a wall-sized stereo display.

CRF facilities are partially supported by the Secure Cyber Operations and Parallelization Studies (SCOPS) instrumentation grant from AFOSR (Contract #: FA 99500910389).

Technical Support

The research facilities are staffed by professional systems engineers who are responsible for operating system and network support, miscellaneous hardware and software maintenance, and troubleshooting. These staff members allow individual researchers to avoid spending time on hardware and software problems.

B. EAST CAROLINA UNIVERSITY

East Carolina University is a Doctoral/Research university that enrolls nearly 28,000 students in undergraduate, graduate and professional programs. Established in 1907, the institution began as a Teachers Training School, became a four-year college in 1920, and became East Carolina University in 1967. In 1971, the North Carolina General Assembly restructured public higher education in the state, making East Carolina University a constituent institution of the consolidated University of North Carolina System. There are 16 campuses in the UNC system.

The ECU campus is centrally located in Eastern North Carolina. The main campus on 530 acres has more than 4.6 million square feet of academic, research and residential space in 158 buildings. The Health Sciences Campus is 206 acres with nearly 1.3 million square feet of academic and research space in 62 buildings. The West Research Campus is 650 acres with 33,000 square feet of research space in 7 buildings.

East Carolina University is part of the UNC system and receives reduced rates at all UNC system core facilities, including UNC Chapel Hill and NC State Universities in the Research Triangle, approximately 100 miles from ECU.

RESEARCH FACILITIES--East Carolina University

Dr. Oyen's Laboratory Facilities

Dr. Oyen's lab is located on the 4th floor of the Ross Hall School of Dental Medicine in the interdisciplinary Basic Science Research Facility. The research facility includes dedicated rooms for tissue culture, microbiology, virology, microscopy, as well as fully equipped laboratories for performing molecular biology, cell biology and pharmacologic chemistry research. Dr. Oyen has approximately 1000 sq. ft. of bench space in the 5,700 sq. ft. main lab, and separate tissue culture and chemical hood rooms, at 120 sq. ft. each. Investigators and research staff have personal office space within close proximity to each other, conducive to collaboration and discussion. Students and post-doctoral fellows have assigned workstations in shared office space near the investigator offices. All offices and workstations have internet and telephone access. In addition to fixed computers running the mechanical testing machines and electrospinner (below), there are two computational workstations with Intel Xeon (R) 4 GHz CPUs and 32 GB RAM. Further computational facilities are available through the Department of Engineering virtual machines.

Equipment

A suite of ***mechanical testing instruments*** across a force range from nN to kN, including:

- Zwick Roell 2.5 kN electromechanical testframe, retrofit with current control and data acquisition software
- TA Electroforce 5500 low-force mechanical testframe with 200, 25, and 2.5 N load cells
- Optics11 Life Piuma nanoindenter

A computer-controlled ***electrospinning*** system:

- Spraybase 20 kV electrospinning kit
- Spraybase rotating drum kit

FTIR (Fourier transform infrared) spectroscopy:

- Bruker Lumos II FTIR microscope with attenuated total reflection (ATR)

For manufacture of microfluidic molds and surface treatment of devices:

- Dremel Digilab ***3D printer***
- Harrick ***plasma cleaner***
- ***UV Lamps (2)***

Dr. Hannan's Laboratory and Animal Facilities

Dr. Hannan's main laboratory (LSB 254: 800 ft²) is in the Edward Warren Life Sciences Building (LSB), which adjoins the Brody Medical Sciences Building. The laboratory has dedicated bench space for in vivo animal physiological sexual function assessments (2 stereo dissection microscopes, isoflurane anesthesia machine, Grass stimulator, fluid filled catheters,

powerlab and bridge amps), myograph tissue bath experiments (5x620M and 3x820M DMT myographs), and cellular and molecular biological techniques (Thermo nanodrop 2000C, temperature gradient thermocycler (Applied Biosystems), and QuantStudio™ 6 Flex Real Time PCR System (Applied Biosystems)). A 100 ft² behavioral testing space is equipped with 2 video cameras and plexiglass bottomed chambers to assess erectile function in conscious animals using the apomorphine bioassay. A 1200 ft² cell culture suite (LSB 271) is located on the floor with a dedicated hood, bench space and incubators. A fully equipped histopathology laboratory is on the floor with a tissue processing system, embedding station, microtome and several light and fluorescent microscopes. The lab also two-door deli fridge, freezers, and ultralow freezer (-80°C), bench top centrifuges, ultracentrifuges, circulating and shaking water baths, dry baths. The Hannan lab is equipped with 6 PCs all networked to laser-jet printers and the internet and linked to a lab specific server that is backed up daily. The labs are equipped with state-of-the-art software for DNA/protein analysis, word processing, graphics, image analysis, and statistical analysis.

Office

Dr. Hannan has 150 ft. of office space on the 2nd floor of the Life Sciences Building. Lab/Student common area are located adjacent to Dr. Hannan's office and there are 4 designated cubicles for students, postdoctoral fellows and technicians equipped with computers and networked to a printer.

Shared and Core Facilities

Dr. Hannan also has access to the East Carolina Diabetes and Obesity Institute microscope facility that houses several Zeiss confocal microscopes for fluorescence microscopy and image acquisition and analysis. The ECU Flow Cytometry-Confocal Microscopy Core Facility, part of the School of Medicine Biotechnology Program, is in an adjoining building and provides state of the art Flow Cytometry and Laser Scanning Confocal Microscopy Services.

All animals are housed and cared for by the Department of Comparative Medicine which operates and maintains over 75000 ft² of animal housing and support space. The animal facility at the Brody School of Medicine is licensed and fully accredited by the AAALAC. ECU complies with the Animal Welfare Act (AWA), the Public Health Service Policy on Humane Care and Use of Laboratory Animals, the Guide for the Care and Use of Laboratory Animals, and the U.S. Government Principles for the Utilization and Care of Vertebrate Animals Used in Testing, Research, and Training. The Department of Comparative Medicine is located on the 2nd floor of LSB down the hall from Dr. Hannan's lab. They routinely run CBC blood panels and assist with necropsies.

Equipment

The following is a list of key equipment already in place in the lab or in facilities that are shared and are essential to the success of the project.

Measurement of ICP/MAP and apomorphine testing: Nikon stereo dissection microscope (2), isoflurane anesthesia machine, Grass Instruments SD9 Square Pulse Stimulator, fluid filled catheters (2), 4 channel powerlab and bridge amps, Lab chart software, Fine Science Tools surgical equipment, Ohaus portable scale, heating pad, 2 video cameras, plexiglass bottomed chambers to assess erectile function in conscious animals.

Tissue bath experiments: 620M DMT myographs (5), 820M DMT myographs (3), 8 channel powerlabs (4), Grass Instruments SD88 Dual Output Square Pulse Stimulators and splitters (2), 4 dedicated PCs connected to internet and printer, Lab Chart software, water baths.

Molecular experiments: Thermo nanodrop 2000C, Applied Biosystems temperature gradient thermocycler, QuantStudio™ 6 Flex Real Time PCR System, plate reader.

Histology experiments: Tissue processing system, embedding station, microtome, Zeiss confocal microscope, Aperio VERSA Brightfield, Fluorescence & FISH Digital Pathology Scanner.

Standard lab equipment: -80C, -20C, 4C refrigerators/freezers, bench top centrifuges, ultracentrifuges, circulating and shaking water baths, dry baths.

Dr. May's Laboratory and Facilities

Dr. May has two private offices of approximately 120 sq. ft., one in Ross Hall on the ECU west campus and one in **Ward** Sports Medicine building on the ECU east campus. She has appointments in the SoDM Department of Foundational Sciences and Research department as well as an adjunct appointment with Obstetrics and Gynecology in Brody School of Medicine and with the Health and Human Performance department on the ECU- East campus. Sufficient administrative support, supplies, as well as research students for this research are available for this project. All students and research staff on the research team additionally have individual desk/office space with standard Mac computers as well as internet and administrative assistance.

Shared and Core Facilities

For consenting, treadmill testing, and exercise training, Dr. May has use of two facilities on the east and west ECU campuses in Greenville, NC. The Human Performance Lab (HPL) consists of 5,000 sq. ft. in the Ward Sports Medicine Building with dedicated space for submaximal and maximal fitness tests: four dedicated treadmills with EKG and metabolic carts, and two cycle ergometers. Additionally, the Ward space has exam tables, additional treadmills, a body scanner, DEXA, private exam room as well as necessary equipment for fitness testing (e.g. blood pressure cuffs, stethoscopes, etc.). The Fitness Testing and Training (FITT) Center is located adjacent to the Ward Building on the East campus with easy access and devoted parking spaces for research subjects. The FITT Center (3,000 sq.) on East campus and the FITT Satellite Center in East Carolina Heart Institute (ECHI; 1000 sq. ft.) on the West campus have dedicated space for exercise training and testing with resistance and aerobic training equipment and private locker rooms. Both facilities have equipment for exercise assessments including Polar heart monitors, blood pressure cuffs, etc.. Additionally, FITT and ECHI have lab areas with standard clinic equipment, equipment for morphometric and body composition assessments, lab supplies for adult and pediatric phlebotomy, centrifuges, onsite cholesterol check, lactate tests, and blood glucose equipment. The FITT and ECHI facilities are equipped to handle emergencies with an emergency drug box and a Phillips defibrillator. All clinic staff are CPR certified and trained for emergencies.

The East Carolina Diabetes and Obesity Institute (ECDOI) on the 4th floor of ECHI on West campus provides access to core equipment such as confocal microscopy, PCR, electron microscopy, scintillation counting, cell culture, freezers (eight -80 upright freezers), and a Unicel Dx600i (Beckman Coulter) automated blood analysis system used for glucose, lactate, and insulin analyses along with other basic laboratory equipment. Lab space is utilized for raising and studying primary human skeletal muscle cell cultures and cultures derived from umbilical cord cells. Dr. May has wet lab space on the 4th floor of Ross Hall (~600 sq. for each lab) on the West campus as well as access to core equipment such as confocal microscopy, electron microscopy, PCR, cell culture, and freezers (eight -80 upright freezers), biosafety cabinets, Milli-Q water purification system, refrigerated benchtop centrifuges, homogenizer, shakers, cold room, BSL-2 lab, along with other basic laboratory equipment.

The Clinical Research Clinic is located on the 2nd floor of Ross Hall (West campus), where Dr. May also has an office, and has 6 exam rooms, a check-in room and lab area. All exam rooms are 120 sq. ft. The research exam room with infant scales, an exam table, mats, and stadiometer is private and enables them to perform neuromotor (e.g. Steps, floor mat, appropriate toys- playground ball, tennis ball, infant/toddler toys, open floor space for running and jumping) and infant morphometric measures (e.g. tape measure, scale) as well as venipuncture. Dr. May's lab area houses standard clinic equipment, lab supplies for adult and pediatric phlebotomy, hood, centrifuges, refrigerated centrifuge, freezer, and onsite cholesterol check and blood glucose equipment. The clinic is equipped to handle emergencies with an emergency drug box and a Phillips defibrillator. All clinic staff are CPR certified and trained for emergencies.

The **Ward Sports Medicine labs** are located on the 3rd floor of Ward Sports Medicine Building. This facility has multiple faculty offices, as well as meeting and conference rooms, telephone and videoconferencing systems, commercial grade printers, wireless computing network, and multipurpose rooms. In addition to research faculty offices, the 3rd Floor of Ward provides additional office space for research project coordinators, research technicians, graduate and undergraduate research students, and administrative staff.

ECU buildings all have wireless capability and all faculty, staff, and students on this project have PC or Mac computers with Windows operating systems and Microsoft Office applications and can access electronic health records at workstations and clinic locations. They have password and firewall protected departmental hard drives for the safety and protection of study data. These protections are HIPAA compliant and are on a scheduled backup within the ECU internal protected system. The IT department provides computer application training, 24-hour helpdesk service, and cleaning/upgrading of computer systems.

The support staff each have offices at the different locations to help provide oversight for study visits. The Research Project Coordinator has an office in FITT (east campus) as well as Ross Hall (west campus), the postdoctoral fellow has an office in Ward (east campus) and Ross hall (west campus), and the doctorate and graduate students have offices in Ward and Ross Hall. This allows research staff to be readily available to assist participants in the study on both campuses.

Equipment

ECU has an interdisciplinary environment supporting collaborative research related to diabetes, obesity, and heart disease with a focus on cardiovascular health, metabolism, as well as pregnancy. For > 20 years, researchers from various departments on both campuses meet every week to discuss ongoing and proposed projects, and to present research and exercise interventions for these diseases. This ECDOL group capitalizes on this synergy and has an institute budget, additional laboratory space, and funded technical personnel. Similarly, the HPL is an interdisciplinary research unit designed to support studies involving exercise and exercise training and provides facilities as well as student and staff support. For example, all investigators on this project have been collaborating and have worked to gather the preliminary data for this application. Additionally, ECU has the Pregnancy and Infancy Research Collaborative (PIRC), a group of 20 faculty from diverse departments on both campuses, that meet regularly to develop projects related to pregnancy and offspring outcomes to maximize research efforts, space, and personnel. Altogether, we have an environment with a high probability for success at obtaining pioneering information that will lead to "healthier lives" by preventing disease from pregnancy and beyond.

Analytical services are offered through the **Brody School of Medicine Mass Spectrometry Center** (BSOM MS). Our MS Core facility has laboratory space and equipment available on the Health Sciences (west) campus of East Carolina University in BSOM. Two major pieces of equipment used for this grant application are both housed in Brody School of Medicine,

Room 4S15 (approx. 800 sq. ft.) and 4N47 (approx. 950 sq. ft.). An Ultimate nano-liquid chromatography/Thermo Orbitrap Q-Exactive Plus and an Eskigent 425 micro-liquid chromatography/AB Sciex 5600+ Triple TOF (LC/MS) used for proteomics and metabolomics applications. The equipment is in a BSL-2 laboratory located in the Department of Research and Graduate Studies in BSOM.

Dr. Kim's Laboratory

The Biomedical Instrumentation and Data Analysis (BIDA) lab is housed within the College of Engineering and Technology, which was founded by Dr. Kim in 2012, occupies a 350 sq ft lab space in the Science and Technology Building hosting many lab spaces, classrooms, and offices. The BIDA lab is equipped with three electroencephalogram (EEG) recording devices, two designated MATLAB and data servers, a 42-inch screen setup used to present visual stimuli, and three laptop computers. The EEG recording devices (Guger Technology and Cognionics) use the latest dry-electrodes which do not require any gel. One of them has a wireless connectivity capability. The MATLAB and data servers work in a virtual machine environment to provide ultimate expandability and flexibility and are maintained by ECU technology service that ensures HIPAA-compliance.

Shared Equipment

Ross Hall Research Lab (Oyen and May)

Facilities are available in the Ross Hall research lab via core facilities and via shared instruments with other PIs. This includes instruments in a core **microscopy** facility:

- Zeiss EVO 10 Scanning Electron microscope (SEM)
- Zeiss Confocal LSM 800 with Airyscan
- Nikon Eclipse LV100ND optical microscope with high-speed camera
- Keyence brightfield and fluorescence microscope

Basic **biosciences facilities** and equipment including but not limited to:

- QuantStudio 3 qPCR system (Life Technologies)
- Spectromax M3 plate reader with spectradrop and spectrophotometer (Molecular Devices),
- Multiple -80°C and -20°C freezers and refrigerators plus a walk-in cold room
- Three large and many mini incubators for cells and microorganisms,
- Milli Q Water System
- Analytical and Precision Balances (0.00001g),
- Centrifuges, Homogenizers, Waterbaths, and pH meters.

Clinical Facilities And Sample Collection

The Brody School of Medicine (BSOM) is the medical school at East Carolina University. It grants the M.D. and Doctor of Philosophy (Ph.D) degrees, as well as a Master of Public Health (MPH) degree. The school has a student body of about 470 students and around 450 faculty members and researchers. BSOM organizes research through more than a dozen research centers and institutes, receiving around US \$30 million annually in externally funded grants and contracts. The ECU Department of Obstetrics & Gynecology is located within the BSOM.

Vidant Health is a not-for-profit, 1,447-bed hospital system that serves more than 1.4 million people in 29 Eastern North Carolina counties. The health system is made up of nine hospitals and more than 12,000 employees; their flagship hospital, Vidant Medical Center, is a level I

trauma center and serves as the teaching hospital for the Brody School of Medicine at East Carolina University in Greenville.

ECU has standard protocols and regularly collects placental, and blood samples as well as electronic health record information in conjunction with the Labor and Delivery unit located within Vidant Medical Center Women's Services and Children's Hospital on the same campus as ECU Allied Health campus. As the tertiary referral center for 29 counties in eastern NC, Labor and Delivery delivers ~3700 babies each year; of these births, approximately, 21.9% (810 births) are preterm and 10% (370) are affected by pre-eclampsia.

ECU has an interdisciplinary collaborative research group called Pregnancy and Infancy Research Collaborative (PIRC), comprised of pediatricians, pediatric cardiologists, obstetricians, physiologists, nutritionists, physical therapists, dentists, chemists, engineers, communication specialists, family science specialists, psychologists, bioinformatics specialists, and health disparities researchers. The group focuses on exposures during pregnancy (i.e. drugs, stress, exercise) and the influence on maternal, pregnancy, placental, and offspring health outcomes. An experienced, motivated, interdisciplinary team is able to recruit, retain, and collect measures on pregnant women and children of all races/ethnicities.

With ECU's numerous studies, sustained protocols to consent pregnant women and collect maternal and infant measures in our research labs are located on the 2nd, 3rd, and 4th floor of the ECU Heart Institute (West campus), where there are exam rooms, a check-in room and lab area. All exam rooms are 120 sq. ft. The lab area houses standard clinic equipment, lab supplies for adult and pediatric phlebotomy, hood, centrifuges, refrigerated centrifuge, freezer, and onsite cholesterol check and blood glucose equipment. The clinic is equipped to handle emergencies with an emergency drug box and a Phillips defibrillator. All clinic staff are CPR certified and trained for emergencies.

Protected Health Information

The research technician will handle all forms containing PHI in this study. She will be responsible for having the information from those forms transferred to a data set, which will then be de-identified. The forms containing PHI will then be destroyed. Other researchers in the study will see only de-identified data in the data set.

REDCap

Data will be abstracted from ECU electronic medical records into the Research Electronic Data Capture (REDCap) system, a secure, HIPAA- and FERPA-compliant, web-based application for building and managing surveys and databases. We will access electronic health records to record pertinent pregnancy history and complications (e.g., gravida, parity, infections, GDM, etc.), health (pre-pregnancy BMI), race/ethnicity, labor and delivery course and complications (e.g., type of delivery, preterm delivery, preeclampsia, etc.), and neonatal facts (gestational age, length, weight, sex, abnormalities, hospital stay, etc.).

Exercise Training and Testing

Ward Sports Medicine Building. Three Quinton treadmill/automated EKG stations, six exercise treadmills, two Lode and two Veletron electrically-braked cycle ergometers, one SciFit electrically braked arm ergometer, two Monark Ergometers, three indirect calorimetry analyzers (Parvo Medics), and an environmental chamber. An upper and lower body isokinetic device (Kin Com) is located in the Biomechanics Laboratory which is on the same floor as the HPL.

Fitness Testing and Training (FITT) Center Washer/dryer (for towels), eight treadmills with cable TV (CATV) and internet integrated services, one treadmill/EKG station, six stationary upright bicycles, six elliptical trainers, one recumbent electrically-braked exercise ergometer with CATV service, two recumbent electrically-braked exercise ergometers, one upright electrically-braked exercise ergometer, one rowing machine, free weights, dumbbells, benches, exercise balls, nine resistance training stations/machines which can train different upper and lower body muscle groups (Precor, Cybex, Nautilus) and other training equipment (e.g. resistance bands, stepper, balance board, etc.).

East Carolina Heart Institute: Satellite FITT Center. One Quinton treadmill/automated EKG station, five treadmills with CATV and internet integrated services, seven elliptical trainers, three recumbent electrically-braked exercise ergometers with CATV and internet integrated services, and three Precor weight machines (multi press, leg extension/curl, bicep curl/tricep extension), free weights, dumbbells, exercise balls, and other training equipment (e.g. resistance bands, stepper, balance board, etc.). The facility also includes an administrative support/reception area, a patient exam/prep room, storage, and two locker rooms with showers. The facility is staffed by master's degree graduate students from the Human Performance Laboratory, Kinesiology Department.

Clinical

Ward Sports Medicine Building. DEXA (Lunar Prodigy), three treadmill/automated EKG stations, three indirect calorimetry analyzers for exercise or RMR. A Bod Pod for research use is located in the Physical Activity Laboratory in an adjacent building (Minges Coliseum). We also have a 3D scanner for the measurement of body circumferences and body composition analysis digitally using safe, laser light technology.

East Carolina Diabetes and Obesity Center Clinical Research Space. Two hospital beds, two reclining chairs, autoclave, CATV, refrigerated centrifuge, analytical scale, refrigerator/freezer, one indirect calorimetry unit, biological safety hood, pre-analytical blood and tissue handling. The ECDOI Clinical Research Space is located on the 2nd floor of clinical facilities of ECHI (same building) and includes private beds, nursing station, a sample processing room with appropriate equipment (centrifuges, balances, etc.) for provided services (Muscle Biopsy, Blood Draw, IVGTT, OGTT, Microdialysis, Fat Biopsy, Resting/Exercising-EKG), and a private 200 sq. ft. office. ECDOI also includes ~8000 sq. ft of Translational Research and Outreach space in the adjacent Warren Life Sciences building which includes office, patient exam, and conference space.

Ross Hall Clinical Research Center. Two open exam rooms, three private exam rooms, CATV, one reclining chair, a refrigerator/freezer, one refrigerated centrifuge, centrifuge, bench space, fume hood, a microscale, -80 freezer, pre-analytical blood and tissue handling. Within our exam room we have infant scales, exam table, reclining chair, stadiometer, floor mats, moveable steps (for neuromotor assessments), and equipment for adult and pediatric venipuncture.

Wet Lab

Labor and Delivery - Vidant Medical Center Women's Services and Children's Hospital. 50 beds and a designated wet laboratory area with a microcentrifuge, materials for blood and tissue processing), a refrigerator/freezer, one refrigerated centrifuge, centrifuge, -80°C freezer, and a sterile bench space.

Ward Sports Medicine Building. centrifuges, reagent grade water system, -80 C freezer, refrigerator/freezer, fume hood, ice machine, pH analyzer, glassware, pipets, fume hood.

C. UNIVERSITY OF CALIFORNIA, IRVINE

The University of California, Irvine (UCI) offers a dynamic learning and research environment that encourages multidisciplinary work and provides regular funding opportunities and workshops for interdisciplinary discourse and research. UCI emphasizes strong ties to the community in research, education, medicine, practice, and service. This emphasis and the University's commitment to working with other institutions, teachers, and students will contribute to the successful conduct of the proposed project.

UCI, a member of the American Association of Universities, is designated by the U.S. Department of Education as a Hispanic-serving institution (HSI) and as an Asian American and Native American Pacific Islander-serving institution. The HSI designation helps the University support first-generation and low-income students with federal funding that is used, in part, to boost student financial aid and other student services. Currently, more than 26% of UCI's undergraduate students are Hispanic. These large Hispanic student enrollments will help ensure that we are able to recruit undergraduate students for this project who will serve as the program's participants.

The University of California, Irvine (UCI) offers a dynamic learning and research environment that encourages multidisciplinary work and provides regular funding opportunities and workshops for interdisciplinary discourse and research. UCI emphasizes strong ties to the community in research, education, medicine, practice, and service. This emphasis and the University's commitment to working with other institutions, teachers, and students will contribute to the successful conduct of the proposed project.

RESEARCH FACILITIES

Drs. Liu, Downing, and Chesler Laboratory Facilities

The laboratories of **Drs. Liu, Downing, and Chesler** are located within the Edwards Lifesciences Center for Advanced Cardiovascular Technology (ELCACT), which occupies approximately 13,000 sq. ft. on the second floor of Engineering Hall at the University of California at Irvine. Each individual PI has approximately 900-1100 sq. ft. of dedicated laboratory space within the Center, which includes bench space for researchers to conduct biological and basic materials-based experimentation. The Center also contains multiple core laboratory spaces shared by six laboratories. The individual laboratories and core laboratories are equipped with the following:

General purpose equipment

General equipment includes chemical fume hoods, centrifuges, refrigeration, ovens, sonicators, shakers, hot/stir plates, dishwashers, sinks, UV ozone cleaners, spin coaters, and storage space for supplies and chemicals. An autoclave, ice machine, incubated shaker, gel electrophoresis and imaging equipment, fluorescence and absorbance plate reader, Nanodrop spectrophotometer, and lyophilizer are also available within ELCACT.

Tissue culture facility

The tissue culture core is equipped with 6 CO₂ incubators, 6 biosafety cabinets, 2 benchtop centrifuges, 3 tissue culture microscopes, -80°C freezer, -20°C freezer, refrigerator, RT-PCR, water filtration system, analytical balances, pH meter, and histology equipment.

Molecular biology equipment

NanoDrop One Spectrophotometer, Qubit 3.0 Fluorometer, Agilent 2200 TapeStation instrument (for RNA, DNA and protein analysis), EVOS FL Imaging System (for fluorescence imaging and hESC colony picking), 4D-Nucleofector cell transfection system, Mastercycler Pro S (pre-Next Generation Sequencing PCR), Sonifier SFX250 w/ 1/8" microtip, Oxford Nanopore MinION sequencer.

Microscopy facility

The microscopy core is equipped with multiple imaging modalities including confocal, fluorescence, differential interference contrast, phase contrast, darkfield and brightfield microscopy. Equipment includes an inverted fluorescence microscope (Nikon) equipped with motorized stage and live cell imaging chamber, an upright fluorescence microscope (Nikon), and a confocal microscope (Zeiss).

Mechanical testing facility

The mechanical testing facility is equipped with instrumentation for static and dynamic mechanical measurements including the Synergie 100 system, which performs quasi static tension or compression and fatigue testing and an Anton Paar Rheometer, which performs rotational and oscillatory tests.

The laboratory of **Dr. Joshua Mauney** is located at the UCI Medical Center on the third floor of Bldg. 55 and consists of ~1000 sq. ft of research space. The laboratory is fully equipped for molecular and cellular biology, histochemistry/histology, mechanical testing, and biomaterial processing. Dr. Mauney also has an additional 250 sq. ft. of laboratory space in the School of Engineering located on the main UCI campus. At the UCI Medical Center in the Edward Shanbrom MD Hall, Bldg. 55, Dr. Mauney has access to the following:

Tissue processing and analytical equipment

-80C and -20C freezers, refrigerators, microwaves centrifuges, ultracentrifuges, UV/VIS spectrophotometers, a CO2 water-jacketed incubator, an HPLC system with autosampler, diode-array detector and software for data collection and analysis (System Gold® HPLC system and 32 Karat™ Software, Beckman Coulter Inc., Fullerton, CA), a microtome with blade sharpener, a tissue embedder, a tissue processor, an American Optical inverted dissecting microscope, and various electrophoresis equipment for Western, Western-ligand and Northern analyses. The laboratory has pH meters, shaking incubators, a Real-time PCR thermocycler (Bio-Rad MyiQ), homogenizers, a water bath, an orbital shaker, a Coulter counter, a UV crosslinker, a transilluminator, an imaging densitometer, a illuminometer, a flow cytometer, a fluorometer, computer scanner with color laser printer, and analytical balances. In addition there is a PCR, MyiQ real-time instrument.

Microscopy and imaging

There are several optical microscopes with accessories including a fluorescent microscope, inverted microscopes with photographic capability, and a light microscope with computerized digital camera. The lab is equipped with fume hoods, biosafety hoods and a sonicator. MRI scanners including a 7T and new 9.4T Bruker small animal MRI systems are also available. The UCI Pathology Research Core also contains a variety of histological and imaging equipment to analyze regenerated tissue samples as needed. X-ray, fluoroscopic, urodynamic, and in vivo imaging equipment are also available at the UCI Medical Center animal facility to support this project.

Animal

Federally compliant facilities for small (rodents) and large (rabbits, sheep, mini-swine) animal surgery and care are operated by University Laboratory Animal Resources on the main campus and at the UCI Medical Center campus. Laboratory space includes operating rooms, post-surgery recovery rooms, radiology, and diagnostic lab services. Survival surgeries can occur in the fully equipped, Medical Sciences shared procedure rooms 113A and 113C. Animals can be housed in the Medical Sciences A Vivarium and air-conditioned pens are available for mini-swine. Assistance by staff veterinarians, surgical staff, and husbandry personnel are available through University Laboratory Animal Resources. UCI's animal care and use program is accredited by the Association for the Assessment and Accreditation of Laboratory Animal Care International (AAALACi). The Institutional Animal Care and Use Committee (IACUC) provides oversight and protocol support.

Computer

The campus Office of Information Technology (OIT) provides computing, networking, and data warehousing services in support of research at UCI. OIT provides central computing services, computer laboratories, machine colocation in data centers, departmental and research group support services, and campus-wide technical coordination. The campus network infrastructure maintained by OIT makes available wireless and/or wired network access to the internet in virtually every area of the campus. OIT provides all faculty, staff, and graduate students with access to Google Apps for Education, which provides essentially unlimited cloud storage of research and other documents to facilitate collaboration. Campus-hosted service for document sharing and collaboration is available via Webfiles, a file storage system that allows each user 1 gigabyte of disk space for storage of important documents and facilitates collaboration with colleagues. Within the School of Education, the Technical Services Group offers Windows 2008R2 as a primary research file server supporting approximately 1 TB of data space and providing for collaborative sharing of files and programs for research; data is backed up daily.

Computer equipment include dedicated systems for the fluorescent microscopes located within ELCACT, as well as an additional shared office computer for trainees, and personal computers exclusively for use by each of the faculty members. The Henry Samueli School of Engineering and the Campus have additional computer laboratories equipped with COMSOL and ABAQUS software packages. Access to the Molecular Modeling facility in the Dept. of Chemistry, with Silicon Graphics workstations and molecular modeling software such as Biosym and MacroModel, is available as well.

Office

Each faculty member has dedicated office space of approximately 150 sq. ft. on the main campus. Desk space for students and researchers are built into the research laboratories.

Other Equipment And Shared Facilities

UC Genomics High-Throughput Facility (GHTF) The UCI Genomics High-Throughput Facility (GHTF) (Director, Dr. Suzanne Sandmeyer) has been in operation since 1999 and currently offers microarray and next generation DNA sequencing support for clients within and outside the University of California system. The GHTF is a Shared Resource funded in part by the Chao Family NCI-Comprehensive Cancer Center Support Grant (P30CA062203) from the National Cancer Institute. Depending on client needs, the facility can prepare mRNA, small RNA, genomic, ChIP, methyl and exome sequencing libraries. GHTF staff have experience with multiple strategy options for exome enrichment, ribosomal RNA depletion and generation of multiplex libraries in order to insure maximal return of data from experiments.

Instrumentation: The GHTF is equipped with a Covaris S220 focused sonicating shearer; Sage Sciences Blue Pippin electrophoresis system for DNA sizing and protein

fractionation, NanoDrop 1000 and One Spectrophotometer, Qubit 1.0 and 3.0 fluorometers, MJ Research Tetrad thermal cycler, Agilent 2100 Bioanalyzer, and Agilent MX PRO RTPCR to facilitate the preparation of libraries and quality testing and final titration of samples. The Fluidigm C1 single cell autoprep system for capturing single cells and preparing templates is available for single cell genomic applications. For higher throughput single cell analysis, the 10x Genomics Chromium is available for single cell RNA 3'-end sequencing or genome and exome DNA sequencing. The Affymetrix microarray platform is utilized for gene expression studies, and analyzing known DNA SNPs and CNVs. Sequencing is currently performed using the Illumina sequencers, MiSeq, HiSeq 2500 with a dual mode system for either high output or rapid mode sequencing, HiSeq 4000 and NovaSeq 6000. For long reads, the GHTF offers Pac Bio Sequel II long-read sequencing, a capability that is useful for whole genome assembly; targeted RNA sequencing for identification of alternative splice variants; targeted DNA sequencing for haplophase genotyping, and for direct sequence identification of base modifications. Digital gene expression and miRNA analysis is performed on the NanoString. Long-range genome optical mapping for genome assembly or identification of structural variants is performed on the BioNano Saphyr system.

Software and Bioinformatic Analysis (supported by **Dr. Jenny Wu**): All sequence data from the GHTF are piped to the Institute for Genomics and Bioinformatics (IGB) where they are analyzed using an Illumina pipeline or PacBio RS software. The IGB is under the supervision of Professor Pierre Baldi (UC Irvine, Information and Computer Sciences; Director, IGB). Data is reported to users as aligned or not aligned fastq files depending on user specification. Software programs including Genomics Workbench (CLC Bio), and Ingenuity Analysis software are installed in the GHTF for client data analysis. GHTF administers the license for Qiagen Ingenuity Pathway Analysis and clients may purchase an annual subscription. Clients of the GHTF have access to the campus high performance computing (HPC) cluster for analysis of sequences involving large amounts of data processing. The HPC is a condo-cluster consisting of almost 8500 CPU cores, ~49 TB aggregate RAM, and 8 Nvidia Tesla GPUs, with Quad Data Rate (40Gbs) Infiniband interconnects. There are ~2PB of storage with 650TB in 2 BeeGFS parallel distributed file systems, and the rest available from ~34 public and private NFS automounts. UCI was funded by NSF for a campus-wide 10 Gbps data network to which the Institute for Genomics and Bioinformatics, HPC cluster and GHTF in Sprague Hall are connected. HPC currently has over 1000 software packages installed, including statistics software such as R and SAS, as well as a large group of bioinformatics tools including bowtie, samtools and cufflinks, which can also run through the Galaxy Portal, a user friendly interface.

Staff: Dr. Suzanne Sandmeyer (Professor, Dept. of Biological Chemistry) is faculty director of the GHTF, and Dr. Melanie Oakes (Dept. of Biological Chemistry) is the facility manager and provides pre- and post-consult for GHTF users. An experienced staff works with clients in training, quality control measures of samples, library preparation, and provides users with the fastq files from the various sequencing platforms. GHTF bioinformaticist, Jenny Wu, Ph.D., supports clients in post-pipeline analysis on a recharge basis. Consultation for planning experiments and for grant writing in the areas of microarrays, next generation sequencing and bioinformatics and statistics is available and encouraged.

Training: The GHTF offers monthly/quarterly training workshops and tutorials in Linux and Open Source software on the HPC cluster as well as Bioinformatics (in conjunction with HPC staff) and also offers classes in *BigData* processing (with faculty in Information & Computer Sciences). The GHTF is committed to bringing new technology platforms to the campus and regularly sponsors technology seminars.

Institute for Genomics and Bioinformatics (IGB) offers expertise in all experimental designs utilizing high-throughput sequencers and expression arrays. The Institute is supported by nine core Program Area Leaders, representing the breadth of IGB inquiry. These research areas are Biochemical Engineering, Chemical Biology, Drug Discovery, Evolutionary Genomics, Medical Informatics, Functional Genomics, Disease Genomics, Structural Genomics and Systems Biology. The Institute for Genomics and Bioinformatics provides consultation and collaborative bioinformatics services.

High Performance Computing (HPC) Cluster is a 7332 core/1PB Condo Cluster available to all researchers at UCI (available to individual PIs preferentially). While the HPC facility is not HIPAA-compliant, appropriately anonymized human data is being reduced and analyzed through various pipelines on HPC. The Cluster also has a large group of bioinformatics tools specifically for biologists including the bam/sam/bedtools, tophat, bowtie, bwa, wgs, trimmomatic, repeatmasker, fastx toolkit, emboss, tacg, Bioconductor, BLAST, Trinity, GATK, Annovar, velvet, vcftools, cufflinks, smrtanalysis, the SOAP tools, picard, and the Bio (Perl|Python|Java) toolkits. The HPC offers very large computing resources to all UCI researchers to allow them to store and analyze data of a size that would not otherwise be possible locally, and personal assistance in resolving specific computational problems. The HPC also offers classes and tutorials in using Linux and the HPC cluster as well as Bioinformatics and also offers classes in BigData processing, facilitating conditions ideal for cross-departmental learning.

Integrated Nanosystems Research Facility (INRF) is a core facility located in Engineering Gateway, which is within 100 feet of Engineering Hall. INRF is a shared campus resource clean room, class 1000/10000 facility with class 100 work areas. The facility houses equipment for photolithography, thin film deposition and material growth, dry etching, wet etching, furnaces and ovens, packaging, sample preparation, and a variety of additional analytical capabilities including SEM and ellipsometry. Training, maintenance and common supplies are all provided by the INRF on a fee-for-use basis.

Beckman Laser Institute (BLI) has four biophysical labs that are equipped with over 30 research lasers and associated power detectors, spectrometers, oscilloscopes, and optical benches. The BLI has an 800 sq. ft. histopathology suite that includes both a scanning and transmission electron microscope as well as a sectioning room, and a room for biochemical preparation for immunohistochemical staining. The BLI houses a Zeiss Meta LSM 510 system capable of confocal, multiphoton, and second harmonic generation imaging.

Gross Hall Stem Cell Building houses the faculty members of the Stem Cell Institute, and is equipped with core facilities available to users for a fee. Equipment include a BD LSR II flow cytometer, BD FACSAria II cell sorter, Miltenyi MACS magnetic cell separator, confocal microscope (Zeiss), Zeiss apotome with stereology. A liquid handler (Beckman) is available for large scale multiwell microplate assays. Nucleofactors (Amaxa) and electroporators (Bio-Rad) are available for cell transfection. Histology services are available with cryostat, microtomes, and tissue embedding equipment as a core lab service. An IVIS Lumina imager is available for whole animal bioluminescence and fluorescence imaging.

Laboratory for Electron and X-ray Instrumentation (LEXI) is a shared facility located in Calit2 and Engineering Tower, both of which are approximately 100 feet from the laboratory of the PI. Equipment available includes a wide range of materials characterization instrumentation and techniques including 3D light microscopy, 3D vibrometer and surface metrology, scanning electron microscopy, focus ion beam, energy dispersive spectroscopy, electron backscatter diffraction, transmission electron microscopy, atomic force microscopy,

and X-ray different, with a comprehensive specimen preparation facility. All usage is on a fee-for-service basis.

Optical Biology Core (OBC) facility is located in McGaugh Hall and provides state-of-the-art instrumentation and technical support for microscopic imaging of biological processes. The facility is equipped with three confocal microscopes (two Zeiss LSM510 META, one Olympus FV1000) mounted on inverted microscopes (Zeiss Axiovert 200M, or Olympus IX81). One LSM510META is equipped with a Spectra-Physics Mai-Tai Ti:Sa ultra-fast laser that permits multi-photon imaging. This instrument is also equipped with DIC optics as well as a META-detector, which can analyze emission wavelengths of different fluorophores between 350 to 800 nm with 11-nm resolution. Each instrument is equipped with a wide range of high NA, strain-free objectives ranging from 5x to 100x. Data acquired using these systems are analyzed using licensed Zeiss LSM Software. The OBC's Director (Dr. **Adeela Syed**) is available to provide technical expertise for training and support on an as-needed basis.

The Laboratory for Fluorescence Dynamics (LFD) is a national research resource center for biomedical fluorescence spectroscopy, jointly supported by the National Institute of General Medical Sciences (NIGMS) and the University of California, Irvine. Located in Natural Sciences II building where it occupies ~8,000 sq. ft., the LFD provides a state-of-the-art laboratory for fluorescence measurements in addition to technical assistance. Resources are maintained for spectroscopy, microscopy, biochemistry, cell culture, and data analysis. Research capabilities range from probing structure and function of biomolecules and membranes in-vitro using steady-state and time-resolved optical spectroscopy, over temporally and spatially correlating and tracking biological processes in cell and tissue cultures using fluorescence microscopy, to non-invasively monitoring physiological processes in live plants, animals and humans. Key equipment includes commercial one/two-photon confocal laser scanning microscopes with added FLIMBox devices and/or 3D tracking capabilities

The School of Biological Sciences Shared Facilities has established a cluster computing resource housed and supported within the UCI Office of Information Technology (OIT). This "bio" cluster consists of twenty-two 64-core compute nodes, the majority of which have 512 GB of RAM. Seven of these nodes are freely available to all researchers within the School of Biological Sciences, and the remainder are private nodes belonging to specific labs and/or groups. The cluster uses Open Grid Engine to manage job submission to nodes, giving priority access to private queues while also allowing those nodes to be used by other researchers in the biological sciences when available. The Open Grid Engine system also provides access to nodes outside of the School of Biological Sciences when they are not in use, providing up to another thirty 64-core nodes. The system is flexible enough that compute nodes purchased for specific projects can be associated with project-specific queues for priority access. The "bio" cluster currently has 340TB (terabytes) of shared storage connected to the compute nodes via an InfiniBand network. The storage units deploy Gluster, a high-performance file system capable of handling the large I/O loads required for modern computing tasks in the biological sciences. OIT supports the "bio" cluster with two full-time staff members who handle all hardware- and software- related needs of campus researchers. The administrators recommend that heavy users contribute compute and/or storage nodes. Contributed nodes are administered for free, and always available to the purchasing PI as a private node (when the owner starts a job, non-owner jobs are suspended). The recommended compute nodes have 64 cores, 512 GB of memory, and can connect to the InfiniBand network. In addition, Bio. Sci. has a full-service optical biology facility equipped with several state-of-the-art confocal microscopes, including Zeiss LSM710 and 780 machines, as well as a Nikon Spinning Disc confocal microscope, suitable for time-lapse analyses. There is also a Biacore instrument for measuring molecular interactions, a cell sorting facility and an Affymetrix microarray facility on campus.

School of Physical Sciences Shared Facilities include several facilities for chemical analysis. An NMR facility equipped with four Bruker Advance spectrometers, one of which is equipped with a highly sensitive cryoprobe. A separate biomolecular spectroscopy facility is equipped with a spectrometer set up for biomolecular specimens. The Laser Spectroscopy Facility is a resource facility at UCI that is equipped with dynamic light scattering, circular dichroism, FTIR, spectrometer, and spectrofluorometer.

UCI Center for Statistical Consulting: The UCI Center for Statistical Consulting and the NIH-funded Institute for Clinical and Translation Science Biostatistics, Epidemiology & Research Design (BERD) Unit contribute to the acceleration of research discoveries by providing exceptional biostatistics collaboration and education. This center supports UCI researchers on all types of projects, ranging from brief consultations for statistical advice to long-term partnerships on large, interdisciplinary-program projects, multi-center trials, and population-based studies. The Center provides a broad range of services to affiliated investigators. Specific consultation and collaboration services include: grant proposal preparation, leadership on program project statistical and data coordinating cores, study design and statistical analysis plans, power and sample size calculations, data analysis and interpretation, manuscript/poster/abstract review and preparation, response to reviewers, IRB applications, training in the use of statistical software, and research database design.

D. UNIVERSITY OF PITTSBURGH

The University of Pittsburgh (Pitt) is a world-renowned, public, state-related research university, founded as the Pittsburgh Academy in 1787. Its charter was altered in 1819 to confer university status and was renamed the University of Pittsburgh in 1908 by state legislative act. Pitt was a private institution until 1966, when it became part of the Commonwealth System of Higher Education. The 132-acre Pitt main campus is located in southwestern Pennsylvania along with its affiliated University of Pittsburgh Medical Center (UPMC), in Pittsburgh's Oakland neighborhood. Pitt currently has more than 8.8 million square feet of academic, research, and residential space.

Pitt is a member of the Association of American Universities (AAU), which comprises 63 preeminent doctorate-granting research institutions in North America. With more than 33,000 students enrolled annually in undergraduate, graduate, and professional programs, Pitt currently offers 645 certificate and degree-granting programs at its main and four regional campus locations. Pitt ranks 9th nationally in federal science and engineering funding according to the National Science Foundation, with nearly \$900M in sponsored research expenditures in fiscal year 2020, and has a strong commitment to providing research opportunities for undergraduate and graduate students

RESEARCH FACILITIES

Dr. Abramowitch's Translational Biomechanics Laboratory (TBL)

The facilities include 3 laboratories with 2,100 sq. ft. of total space in the recently renovated Benedum Hall at the University of Pittsburgh.

The laboratories are designed for mechanical testing of tissues and biomaterial and computational modeling. For the former, there are 5 different mechanical testing machines that are capable of handling combinations of high/low force, high/low deformation, and high/low strain rate testing with the capability of high-resolution strain tracking. For the latter, it has 10

Macintosh desktop and laptop computers. The computers are networked for maximum efficiency, both within the laboratory as well as within the greater university. We also have access to the University of Pittsburgh's Center for Research Computing.

Library Services:

Falk Library of the Health Sciences is the flagship library of the Health Sciences Library System and serves the Schools of Nursing, Dental Medicine, Health and Rehabilitation Sciences, Medicine, Pharmacy and the Graduate School of Public Health. The library houses more than 300,000 volumes, receives over 2,100 journal subscriptions, and includes the History of Medicine collection with over 15,000 volumes featuring rare books on medicine, nursing, psychiatry, and public health. To assist faculty with their literature searches, trained reference librarians are available from 8:30 am to 5:30 pm Monday – Friday and 9:30 am to 5:30 pm Saturday. HSL Online provides access to databases and electronic resources to faculty, staff, and students. HSL Online offers access to approximately 50 bibliographic databases including CINAHL (Cumulative Index to Nursing and Allied Health Literature), MEDLINE (biomedical journal literature), CancerLit, Health & Psychosocial Instruments, PsycINFO, Health Reference Center, Micromedex, PubMed and many more. HSL online includes access to 2,500 full-text electronic journals and more than 400 full-text electronic textbooks. The University's online catalog, PittCAT, provides information about the availability of materials at all University of Pittsburgh libraries.

Center for Research Computing

Access to computing hardware, software, and research consulting are provided through the Pitt Center for Research Computing (Pitt CRC). CRC provides in-house high-performance computing (HPC) resources allocated for shared use for campus researchers.

Pitt CRC provides state-of-the-art HPC clusters. The clusters comprise 136 24-core Xeon Gold, 29 12-core Xeon E5, 20 16-core Xeon E5, 132 28-core Xeon E5, and 32 20-core Xeon E5 compute nodes, totaling to 8268 computation-only CPU cores.

There are an additional 33 GPU dedicated nodes with a total of 128 Titan class or better GPUs. The nodes have a range of 62 GB to 125 GB per node shared memory. The global storage consists of a 130 TB Isilon home space (which is backed up), two 500 TB ZFS file systems, and a 1.6 PB BeeGFS parallel file system.

The systems are housed at the enterprise-level Network Operations Center (NOC) and are administered jointly with Pitt IT. Pitt IT maintains the critical environmental infrastructure (power, cooling, networking, and security) and administers the cluster operating systems and storage backups. CRC interfaces directly with researchers and provides software installation services, training workshops, and personalized consultation on improving software design/performance and computational workflows.

Dr. Ibrahim's Laboratory Facilities

7 Tesla (T) Bioengineering Research Program

- 7 Tesla (T) human MRI scanner is housed in the basement of the Biomedical Science Tower 3, the same building and floor as the RF Research Facility. A description of the 7T System is provided in the Equipment Section.
- A list of the RF coil and array systems currently used for 7T human imaging studies is provided in the Equipment Section.

- Currently, the Department of Bioengineering occupies the 7T Human MRI scanner two full weekdays per week. Scanner bookings and acquisitions are handled by the 7T Bioengineering Research Program.

Radiofrequency (RF) Research Facility

The RF Research Facility (Biomedical Science Tower 3) contains all the necessary equipment for designing and constructing MRI coils/antennas and electromagnetic devices for different types of medical applications. The Facility includes state of the art RF testing equipment. A list of the available RF equipment is provided in the Equipment Section.

Machine Shop

The RF Research Facility includes a mechanical workshop has a lathe and milling machine with accessories for fabrication of metal, fiberglass and plastic supports for antennas, coils and phantoms. A list of the available machining equipment is provided in the Equipment Section.

Computational Capabilities and Storage Systems

The RF Research Facility includes extensive computational capabilities and storage systems. A list of the available computational resources is provided in the Equipment Section.

Equipment

Magnetic Resonance Imaging

7T Magnetom Whole-Body MRI System: This 7T system is a Siemens retrofit of a GE magnet. As part of this retrofit, the scanner was upgraded to 32 independent receive-channels, each of them with multi-nuclear capabilities. The 7T supports parallel transmission capabilities with the addition of a parallel transmission unit from Siemens Medical Systems. This unit provides 8 independent transmission channels.

RF Coil Systems

- 7T Tic Tac Toe RF Head Coil System:
Transmit: 1 to 16 Channels — Receive: Insert Style: 32 Channels (please see below.)
Parallel Transmit/Single Transmit Systems: Works on both
A video projector and audio system along with response gloves are used for stimulus presentation & recording.
- 7T Rapid Biomed Dual Tuned 31P-1H RF Head Coil System:
Transmit: 2 Channels — Receive: 2 Channels
Parallel Transmit/Single Transmit Systems: Single Transmit
- 7T TEM RF Head Coil System:
Transmit: 4 Channels — Receive: Insert Style: 14 Channels
Parallel Transmit/Single Transmit Systems: Works on both
- 7T Tic Tac Toe RF Breast Coil System:
Transmit: 1 to 8 Channels — Receive Insert Style: 8 Channels
Parallel Transmit/Single Transmit Systems: Works on both
- 7T Tic Tac Toe RF Whole-Body Coil System:
Transmit: 1 to 32 Channels — Receive: Insert Style: 16 Channels
Parallel Transmit/Single Transmit Systems: Works on both

- 7T Tic Tac Toe RF Ankle/Foot Coil System:
Transmit: 1 to 4 Channels — Receive: Insert Style: 4 Channels
Parallel Transmit/Single Transmit Systems: Works on both
- 7T TEM Knee RF Coil System:
Transmit: 1 to 4 Channels — Receive: Insert Style: 8 Channels
Parallel Transmit/Single Transmit Systems: Works on both
- 7T TEM Hand/Arm Coil System:
Transmit: 1 to 4 Channels — Receive: Insert Style: 8 Channels
Parallel Transmit/Single Transmit Systems: Single Transmit

Physiological Measurements with 7T MRI

BIOPAC MP160 data acquisition system with *AcqKnowledge* software

At the 7T, we are capable of measuring EEG, ECG, skin conductance, respiration and pulse oximetry data. All signals can be recorded for later analysis and post-processing. Our BIOPAC systems are used as data acquisition solutions for physiology measurement and a Datex monitor is used to measure O₂ and CO₂ levels. Also, we are currently in the process of purchasing the MR-safe blood pressure monitor to further expand our physiological acquisition capabilities.

- BIOPAC MP160
MP160 data acquisition and analysis systems with *AcqKnowledge* software provide a flexible tool for life science research. The MP160 is an Ethernet-ready data acquisition and analysis unit that can record multiple channels with differing sample rates; record at speeds up to 400 kHz (aggregate).
- BIOPAC HLT100C
The Amplifier Input Module is used to connect Smart Amplifiers and other high-level transducers to an MP160 System. It allows for up to 16 Smart Amplifiers or other input signals to be connected.
- BIOPAC EEG100C-MRI
The EEG100C-MRI Electroencephalogram (EEG) Amplifier amplifies bioelectric potentials associated with neuronal activity of the brain and can be used to perform unipolar or bipolar EEG measurements.
- BIOPAC ECG100C-MRI
The ECG100C-MRI Electrocardiogram Amplifier records electrical activity generated by the heart and will reliably record ECG from humans, animals and isolated organ preparations. The amplifier output can be switched between normal ECG output and R-wave detection.
- BIOPAC EDA100C-MRI
The EDA100C-MRI measures both the skin conductance level (SCL) and skin conductance response (SCR) as they vary with sweat gland (eccrine) activity due to stress, arousal, or emotional excitement.
- BIOPAC DA100C
The DA100C is a very low noise and drift differential bridge amplifier that will operate with a wide variety of transducers, including: Pressure, force, strain, displacement, thermocouples, piezo sensors, light sensors, microphones and nearly any other active or passive sensor or transducer. We currently use it for the TSD221-MRI transducer.
- BIOPAC TSD221-MRI

This MR-safe fully pneumatic respiration transducer measures subject respiration (thoracic or abdominal) in the MRI.

- BIOPAC OXY-MRI
OXY-MRI is a stand-alone system for adult human pulse oximetry (SpO₂) in the MRI; the system includes an SpO₂ amplifier and a fiber-optic oximetry sensor for the finger.
- DATEX CAPMONAC ULTIMA
Anesthesia monitor measuring the following parameters: CO₂, O₂, N₂O, curves of capnography, O₂ saturation and exhaled halogenated gases, and alarms for high and low gas limits
- Under Acquisition: NIBP-A-MRI
The NIBP-A-MRI CareTaker4 system measures relative central arterial pressure to provide continuous, noninvasive “Beat-by-Beat” Blood Pressure from at rest humans (≥ 15 kg) in the MRI; measures include Diastolic, Systolic, Mean Arterial Pressure.; heart rate (HR) data is available. The system uses the scientific method of Pulse Decomposition Analysis (“PDA”).

Fully Dedicated Computational Resources

- RF Lab Supercomputer cluster:
 - 352-Core/1.3TB (RAM) 64-bit AMD Opteron architecture
 - 320-Core/5TB (RAM) AMD EPYC architecture
- RF Lab Storinator:
 - 272 Terabyte Raids for storage
- 2 Hi-end Workstations with Intel Xeon Gold, 80 cores and 160 threads total, and 768GB of memory total
- 4 high-end GPUs, with 18432 cuda cores and 96 GB of memory total
- 4 Desktop computers with Intel Core-i7 processors, 16 cores and 32 threads total, 192 GB of memory total, and with mid-end GPU GTX, with 7680 cuda cores and 32 GB of memory in total
- 1 Desktop computer with AMD Ryzen 9 processor, 12 cores and 24 threads, 128GB of memory, and with mid-end GPU RTX with 2304 cuda cores and 8 GB of memory

Machining

- Lathe and Milling Machines
- *RF/Phantom/Temperature Equipment*
 - 12-channel network analyzer
 - DAK: high-precision dielectric measurement system for liquids, solids and semisolids
 - 8-channel fiber optic thermometry
 - Chemistry kits for designing biological phantoms
 - 3D printer

Dr. Maiti’s Laboratory Facilities

Dr. Maiti directs the Computational Biomechanics Laboratory at the Department of Bioengineering, University of Pittsburgh. The lab is located at the Biotech Center, University

of Pittsburgh. Primary research focus of this laboratory is the development of experimentally validated computational models for the prediction of biomechanics of soft tissues. Dr. Maiti has about 10 years of experience in developing state of the art computational methods in the general area of mechanics, and particularly in the area of biomechanics of soft tissues. He is currently committed towards applying his expertise in the study of tissue mechanics in zero-gravity environment. He meets with other co-PIs regularly on a weekly basis to conduct research meetings. Currently, Mr. Rahul Ramachandran and Mr. Ronald Fortunato, two highly motivated PhD candidates, populate the investigator's lab. The lab is currently also hosting two undergraduate researchers, Ms. Nya Perry and Mr. Govardhan Nair.

Institutional support:

Dr. Maiti is currently an Assistant Professor in the Department of Bioengineering, University of Pittsburgh. The university has committed financial support and research time to establish his laboratory. Dr. Maiti's laboratory is housed in the Biotech Center including ~2000 sq ft of research and office space. A system administrator and two support staff support the computing infrastructure in the Department of Bioengineering. Additionally, the School of Engineering has a large support staff to facilitate computing at CSSD (Pitt computer support center). Dr. Maiti's research group also has access to **Pittsburgh Supercomputing Center** for high-performance computing to conduct very large simulations.

Computational Facility:

Dr. Maiti's research group has a state of the art Mac Pro workstation cluster with 6 computers each with 12 core Xeon processors, 32 GB memory and 2 TB hard drive. The lab is equipped with additional 20 TB of storage space for upkeep and maintenance of simulation data. Intel Fortran and C++ compiler along with PETSc parallelization framework is used for the development and maintenance of in house massively parallel finite element software that exploits multithreading capabilities of the workstations. The custom developed code has the capability to run very large finite element models using a number of popular constitutive models and in house tissue failure models.

Dr. Maiti has purchased the licenses for over 20 software and services for the research group, including

- Cubit 15.0 mesher (Sandia National laboratory)
- Trellis FEA mesher (csimsoft)
- Paraview v5.6 (Kitware Inc)
- Autodesk inventor 2019 (Autodesk)
- Mathematica, v11.3.0 (Wolfram Research Inc.)
- Matlab R2018b (Mathworks)
- SigmaPlot v11.2 (Systat software Inc)
- Tecplot 360 2015 (Tecplot Inc.)
- Solidworks 3D CAD (Dassault Systemes)
- ANSYS 12.1 (Ansys)
- Stata SE 15.0 (StataCorp)
- SPSS 25 (IBM)

to facilitate image based solid modeling, finite element mesh generation, simulation data visualization, data post-processing and analysis.

Drs. Moalli's and Knight's Laboratory Facilities

Dr. Moalli has 917 sq ft of laboratory space as well as two tissue culture rooms with laminar flow hoods and 115 sq ft of office space on the 3rd floor of the Magee-Womens Research Institute. The MWRI, which was built in February 1994, has undergone a major expansion, which was completed in June 2007. The Institute has more than doubled its size, and now includes more than 110,000 sq ft of modern laboratory space. The MWRI houses numerous scientists, including those specializing in Cell Biology, Genomics, Proteomics, Epidemiology and Immunology.

Animal

Magee-Womens Research Institute contains about 12,500 sq ft of multispecific laboratory animal space; divided in 17 separate animal holding rooms. The facility has 5 procedure rooms, a clinical pathology lab, a state-of-the-art necropsy room and surgical suites (2); all with the versatility of adapting to different species while complying with strict biosecurity measures. MWRI animal facility is AAALAC accredited since 2002 and in full compliance with USDA and Animal Welfare Act regulations (certificate number 23-R-0090). Facilities are maintained by experienced animal care staff with access to veterinary support.

Other Equipment And Shared Facilities

All faculty of MWRI are also faculty of the University of Pittsburgh. Support systems at the University of Pittsburgh School of Medicine are outstanding. A state-of-the-art medical library with on-line access to most relevant journals is available to all university faculty and staff. High throughput analysis core facilities are designed to provide researchers with access to technologies for genetic analyses. Several Gene Chip Facilities and Bioinformatics Cores are within the medical campus and perform eukaryotic and prokaryotic gene expression profiling using Affymetrix's GeneChip high-density oligonucleotide microarrays as well as microRNA array. Researchers also access a compendium of commercial and academic resources for complex data analysis. Automated sequencing is available to us through the University of Pittsburgh. Access to a fluorescent activated cell sorter (FACS) is available within the Department of Immunology at the University of Pittsburgh.

The Core Imaging Facility is a newly renovated area equipped with a full-service microimaging and analysis suite that features a Nikon 90i, fully motorized upright microscope for capturing high quality and high-resolution bright field, DIC, and fluorescence images. It is run by Nikon NIS Elements software for image analysis. In addition, a Leica TCS-SP2 confocal microscope equipped with Argon and Helium-Neon lasers provides six laser lines for the simultaneous excitation of fluorescein, rhodamine, Cy-5 and other fluorophores. Additionally, a 405 nm laser is available for imaging Dapi and Hoechst. Digital images are recorded on CDs and analyses performed using Metamorph software (Universal Imaging, West Chester, PA). A Perkin-Elmer Ultraview LCI spinning microlens array is available for rapid acquisition of confocal images. This is outfitted with a krypton/Argon mixed gas laser for the simultaneous imaging of fluorescein, rhodamine and far red fluorophores. Both systems are equipped with environmental chambers allowing for the collection of confocal data from living cells.

The Confocal Core at MWRI has a confocal core equipped with a Nikon A1r confocal microscope and Volocity 3-D imaging software. The system has capacity for fixed samples and live imaging, including a temperature and atmosphere-controlled chamber for tissue culture cells. The system is equipped for single plane, Z-stacks, and multi-time point analyses. The core is directed by **Dr. Yanowitz** who is an expert in 3-D image acquisition and is directly involved in training users and experimental design.

The Flow Cytometry Facility that was recently created is located on the 4th floor of MWRI (Room B432), is outfitted with a new, 3 laser LSR II (BD Biosciences): blue (488 nm), red (633 nm) and violet (405 nm). This instrument allows simultaneous analysis of up to 8 colors and is operated by the FACSDiva software. The LSR II is attached to an intranet-connected workstation and to a color printer. Upon acquisition, flow data is automatically transferred to the user's profiles on the institute's storage servers. A shared copy (key) of the FACSDiva software is also available to all users. All researchers at MWRI have access to this instrument, which is overseen by **Anda Vlad, MD, PhD**.

Computer

The IMWEL team has computers with the appropriate software for data management, statistical analysis, and graphics. They have access to the MWRI communications network and data archival system.

Dr. Moalli specifically has an iMac desktop computer with the appropriate software for data management, graphics, and statistics. For protein densitometric analysis, a dedicated desktop computer, complete with a variety of word-processing, graphical and image analysis software (Adobe Photoshop, Power Point), is linked directly to an HP ScanJet 5370C scanner. We also have access to a Proteinsimple FluorChemE gel scanner, which, through connection with the network, enables lab personnel to upload images to the aforementioned dedicated desktop computer for densitometric analysis. Densitometric analysis is completed using UN-SCAN-IT gel and graph digitizing software, Silk Scientific, Inc. For appropriate mathematical analysis of ELISA assays, a desktop computer has been equipped with MasterPlex 2010, Hitachi Solutions, Ltd. All lab computers are connected to a Konica Minolta Bizhub 223 which enables us to print, copy, and scan documents. Computers in the lab are networked and have access to Internet services. All computers allow us to log onto the Research Institute Local Area Network, which provides us with the capability of sharing files, printers, and other network resources. Our Research Institute LAN also provides connectivity to all of the University of Pittsburgh servers and mainframe including the University library.

Office

Dr. Moalli has 115 sq ft office space adjacent to her laboratory space on the third floor of the Magee-Womens Research Institute. She has full time secretarial support.

Library Services

Falk Library of the Health Sciences is the flagship library of the Health Sciences Library System and serves the Schools of Nursing, Dental Medicine, Health and Rehabilitation Sciences, Medicine, Pharmacy and the Graduate School of Public Health. The library houses more than 300,000 volumes, receives over 2,100 journal subscriptions, and includes the History of Medicine collection with over 15,000 volumes featuring rare books on medicine, nursing, psychiatry, and public health. To assist faculty with their literature searches, trained reference librarians are available from 8:30 am to 5:30 pm Monday – Friday and 9:30 am to 5:30 pm Saturday. HSL Online provides access to databases and electronic resources to faculty, staff, and students. HSL Online offers access to approximately 50 bibliographic databases including CINAHL (Cumulative Index to Nursing and Allied Health Literature), MEDLINE (biomedical journal literature), CancerLit, Health & Psychosocial Instruments, PsycINFO, Health Reference Center, Micromedex, PubMed and many more. HSL online includes access to 2,500 full-text electronic journals and more than 400 full-text electronic textbooks. The University's online catalog, PittCAT, provides information about the availability of materials at all University of Pittsburgh libraries.

Statistical Support Services

All statistical analyses will be performed by a staff biostatistician.

Equipment

Equipment in the laboratory includes a Biosafety hood, -20°C freezer, - 80°C freezer, a refrigerator, 2 high speed tabletop microfuges, XD-1200D precision balance, a spectrophotometer, an isotemp dry oven, and a high temperature oven. Other equipment includes a variety of electrophoresis chambers for RNA, DNA and protein analysis, multiple mini-transblot transfer cells, 2 stationary water baths, one shaking water bath, a maxi-hybridization oven with rotisserie, portable equipment for photo documentation, two microcentrifuges, a UV crosslinker, and multiple wet heat blocks. Additionally, we have designated areas for radionucleotide handling.

All equipment necessary for standard cellular and molecular biology research is available, either within the lab or at the MWRI. Shared MWRI equipment includes a walk-in cold room, diverse freezers, centrifuges (including an Optima TLX ultracentrifuge), shakers, a Packard gamma- and beta-counter and a standard dark room. Major relevant items that are shared among MWRI researchers include an AB 7900HT qPCR system and Primer Express software, various types of thermocyclers (from AB7500, Veriti and alike), a Luminex 100 IS Total Flexible Analyzer System, ultra-speed centrifuges (Sorvall Ultra80, Sorvall RC5C and Sorvall WX Ultra 80) multiple Sorvall and Beckman high speed centrifuges, Speedvacs and drying systems, shakers (New Brunswick Innova 43 large capacity incubator floor and other shakers), a Packard gamma- and beta-counter, digital gel visualization systems (UVP Biospectrum 500, Bio-Rad Chemi Doc), liquid nitrogen facility for central cell storage (Forma CryoMed and Taylor Wharton K Series), diverse types of plate readers (including Molecular Devices Versamax, Spectramax microplate readers, Turner Veritas Microplate Luminometer), and other spectrophotometers, Flexercell Tension Plus System (FlexCell Int. Corp), hypoxia chambers (Thermo Scientific 1025 anaerobic and Coy chambers for in vitro work and a Coy hypoxia chamber for mouse experimentation, equipped with an air-locked side door, enabling cage and animal exchange without exposure to atmospheric air, and controls for FiO₂, humidity and temperature). Equipment also includes diverse types of microscopes (confocal, upright, inverted, stereomicroscopes and microscopes designed for micromanipulations, all from Nikon, Leica, or Zeiss), equipped with digital cameras and image analysis software (Metamorph, Elements and others).

3. TEAM SCIENCE RESOURCE

IMWEL has the good fortune to be able to take advantage of UCI's **Team Scholarship Acceleration Lab (TSAL)**. Formed at the instigation of UCI's Vice Chancellor for Research in September 2017, four researchers who have made the study of team scholarship their primary area of research formed this group. Along with their continued research and advisory work with UCI's leadership, TSAL offers substantial tools and resources. As described in the Narrative's Section 3.b, TSAL's **Drs. Judith Olson, Gary Olson, Dan Stokols and Maritza Salazar Campos** will collaborate with IMWEL to foster the adoption of Team Science best practices by providing a Team Science workshop at IMWEL's kick-off meeting and then conducting an audit of how well IMWEL is incorporating Team Science in years 3 and 5. Dr. Maritza Salazar Campos will also offer on-going counseling available to any and all IMWEL members throughout the life of the center. IMWEL will encourage its postdoctoral researchers, graduate students, and any undergraduate students to take advantage of this rare opportunity to learn and practice Team Science from a group of scholar practitioners steeped in this field.

4. INNOVATION ECOSYSTEM FACILITIES, EQUIPMENT & OTHER RESOURCES

A. COLUMBIA UNIVERSITY

Columbia Technology Ventures (CTV) is the technology transfer office for Columbia University and a central location for many of the technology development initiatives, entrepreneurial activities, external industry collaborations, and commercially-oriented multidisciplinary technology innovations across the university. CTV's core mission is to facilitate the transfer of inventions from academic research labs to the market for the benefit of society on a local, national, and global basis. Each year, CTV manages more than 400 invention disclosures, 100 license deals, and 20 – 30 new IP-backed startups, involving over 750 inventors across Columbia's campuses. CTV currently has over 1,500 patent assets available for licensing, across research fields such as bio, IT, clean tech, devices, big data, nanotechnology, materials science, and more.

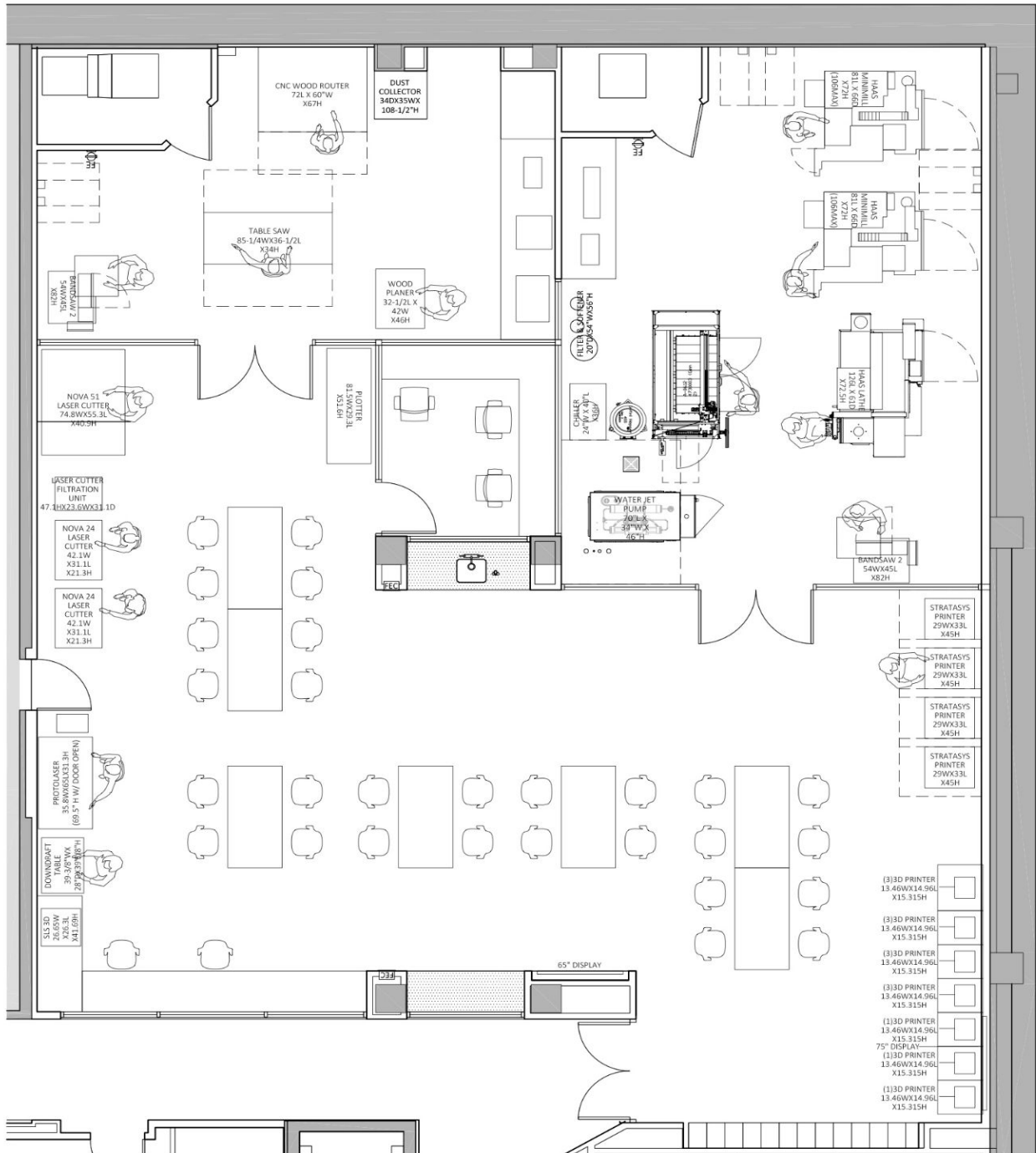
CTV has extensive experience founding and supporting technology initiatives to enable promising technologies to accelerate across the "valley of death" and reach the market as quickly and successfully as possible. Many of these initiatives are explicitly multi-institutional, requiring extensive collaboration with our peer universities and their tech transfer offices. Among the organizations CTV has been instrumental in establishing are **Columbia Biomedical Technology Accelerator (BiomedX)**, formally the Columbia-Coulter Translational Research Partnership. In addition, it launched the **Translational Therapeutics (TRx) Resource** in 2016, in collaboration with the Irving Institute for Clinical and Translational Research and The Clinical Trials Office, to advance novel therapeutics from the lab towards the path of commercialization and clinical implementation.

Forty-five full time staff and an additional 30+ graduate student interns (CTV Fellows) provide broad support to the Columbia community and other stakeholders with marketing, legal (patents, contracts, etc.), business start-up help, and administrative tasks. CTV also runs an **Executive-in-Residence** program that brings seasoned industry executives, serial entrepreneurs, and investors to campus to support faculty and student entrepreneurial activities. A number of Columbia's current executives in residence have backgrounds highly relevant to IMWEL.

IMWEL will take advantage of Columbia's **Program for Diversity and Inclusion in Commercialization and Entrepreneurship (DICE)** that aims to support early-career individuals who identify as being from traditionally underrepresented groups in life science entrepreneurship and commercialization. DICE will provide eligible graduate students and postdocs with educational programming, mentorship, networking, and funding opportunities to prepare participants for careers in bringing life science innovation to market.

Serendipitously, **Alexandria LaunchLabs** is creating a full-service platform to attract life science startups emerging from Columbia and peer institutions on the sixth floor of Lasker, directly above IMWEL Headquarters on floors 4 and 5. Alexandria LaunchLabs describes itself as "premier startup platform for early-stage life science and agtech companies." Its goal is to dramatically accelerate the growth of such early stage companies by providing turnkey laboratory and office space, entrepreneurial support, strategic programming, and access to risk capital. Due to open shortly, the Lasker Building LaunchLab offers 14,000 square feet of collaborative co-working space, including shared and private laboratories and office environments, as well as company-building support and access to seed-stage investment capital through the Alexandria Seed Capital Platform. It also provides a BioMakerSpace (Fig. 3) or creative experimentation and an event space to host workshops, networking and educational opportunities for the entrepreneurial bioscience community. Alexandria

LaunchLabs is enthused about the potential for collaboration as indicated in a letter attached to the proposal.



01 INNOVATION HUB EQUIPMENT PLAN
3/16" = 1'-0"

STEPHEN YABLON ARCHITECTURE
Stephen Yablon Architecture PLLC
306 W. 38th Street
New York, NY 10018
212 868 1665

Columbia University-SEAS Innovation Hub
Columbia University
Mudd Building - Engineering Terrace Wing, 200 Level
500 West 120th Street
New York, NY 10027

ASK-38
07/12/2019
Job #: 1802

Machine	Model	Quantity needed	Quantity on hand
Thunder Laser Lasercutter	Nova 51	0	1
Formlabs SLA 3D Printer	Form 2	0	2
Ultimaker 3d printer	Ultimaker 2 Extended+	7	8
Janome Embroidery Machine	Memory Craft 400e	8	2
Janome sewing machine	HD-3000	8	2
Toyota Sewing Machine	J34 Super Jeans	0	2
Universal Laser Systems Laser cutter	VLS3.50	0	1
Brother 3/4 Thread Serger with Differential Feed	1034D	0	1
Makergear 3D printer	M2	0	1
Pocket NC 5-axis mill	V2 with enclosure	0	1
Bantam Tools PCB Mill	Othermill Pro	0	2
Roland vynil cutter	Camm1	0	1
Cricut vynil cutter	Cricut Maker	0	1
Roland Plotter/cutter	VG540	1	0
Laser Cutter	Nova 24	2	0
Bofa Exhaust	AD 1 Oracle	1	1
LPKF Laser Cutter	S4	1	0
Band saw 2	Doall 2013-V3	2	0
McMaster-Carr Grinder	4601A11	1	0
Grainger Drill press	16N196	1	0
Haas Lathe	ST-10	1	0
Ward Waterjet	A-0612	1	0
Hass MiniMill	MINIMILL	2	0
De Walt Table Saw	DCS7485T1	1	0
Makitatools Miter Saw	LS1019L	2	0
Alztronic 16	16N196	2	0
ShopBot Wood Router	PRS Alpha	1	0
Rockler Wood Work Bench	#31719	1	0
Steelex Wood Planer	ST1007	1	0
Paint/Flammables Cabinet	4495T54	1	0
Stratasys Printer	Dimension 1200es	4	0
Sternvent Dust collector	Vibraclean	1	0

Figure 3: Columbia SEAS Innovation Hub Resources

B. EAST CAROLINA UNIVERSITY

In another event of fortunate timing for IMWEL, East Carolina University announced in February 2021 that the Golden Leaf Foundation had awarded it \$1.9M to create a **pharmaceutical manufacturing training center**. Dr. Harry Ploehn, Dean of the College of Engineering and Technology, is the project's leader. It will draw on faculty expertise from the departments of engineering, technology systems and chemistry as well as the colleges of business and education.

Among the highlights of the project:

- The center will create the **Pharma Pathways Program** in which ECU and community college staff will collaborate to help raise student awareness and provide academic programs, job training and career opportunities in the pharmaceutical industry. The program will be marketed throughout the region, including in military communities, and will provide career planning, scholarships and academic coaching from faculty, staff and industry representatives.
- The center will build and equip the **Manufacturing Capability and Cybersecurity Complex (MCCC)** located in 4,500 square feet of lab space in ECU's new Life Sciences and Biotechnology Building on Evans and 10th streets in Greenville on the Millennial Campus. The MCCC will be a hands-on, experiential education and training environment that will include two 1,200-square-foot teaching labs with new

bioextraction and bioprocessing equipment, and a 1,900-square-foot high-bay lab housing a pilot-scale continuous manufacturing line.

- The center will add three new ECU faculty members and two academic advisors who will collaborate with community college counterparts to increase teaching capacity and develop new courses, enabling the colleges and ECU to expand enrollment in biotechnology and bioprocess manufacturing programs. The programs also aim to introduce pharmaceutical manufacturing topics to students in other disciplines such as chemistry and business that industry partners plan to recruit.
- The center will expand on the **N.C. Pharmaceutical Services Network (PSN@ECU)**, funded by a \$1.1 million Golden Leaf grant to ECU in 2015, offering pharmaceutical manufacturing short courses, employee training and opportunities in which industry partners can test new ideas without disrupting their own manufacturing lines.

The center is expected to attract local companies including Thermo Fisher Scientific, Mayne Pharma, Novo Nordisk, Grifols, Pfizer, and CMP Pharma, which may also provide entry to IMWEL future collaborations.

C. UNIVERSITY OF CALIFORNIA, IRVINE

The School of Engineering hosts **FABWorks**, a new facility with the mission of reinventing the way 480 people create and innovate, offering a space where students, faculty, and the community can design and fabricate almost anything. It houses 3D printers and scanners, vinyl and laser cutters, an electronics lab, a lathe, CNC (automated milling) machines, and a variety of woodshop tools. The secondary students, STEM education center staff and teachers served in the proposed program will have access to the FABWorks facility to work on their projects for advanced engineering equipment needed for portions of the prototyping phase of the program.

The BioENGINE program that serves as the basis for this education project is housed within **UCI Applied Innovation**. The mission of UCI Applied innovation is to help the surrounding community reach its full potential as a national and global leader in scalable innovation through public-private collaboration. It facilitates connections between UCI and industry, including entrepreneurs seeking access to university inventions and talent, large corporations looking to tap the school's research capabilities, and investors wanting to financially support promising new companies. Within UCI Applied Innovation, The Cove is a vibrant gathering place of entrepreneurs and innovators, housing industry organizations, a Small Business Development Center, angel investment organizations, venture capital firms, serial entrepreneurs, and coworking and lab space for university-affiliated companies and teams in a 50,000 square foot space. The Cove hosts a variety of events such as speaker panels and networking mixers aimed at building ties between investors, entrepreneurs, and innovators. Example programs/resources includes the Wayfinder program, a highly-selective incubator program that supports UCI-affiliated startups as they accelerate venture development; over 400 Experts-in-Residence (EiRs); a Small Business Development Center (SBDC @ UCI); and an NSF-funded Innovation Corps (I-Corps). The I-Corps program is a four-week market discovery program that leads campus innovators through an immersive learning process to discover their product's place in the market; UCI I-Corps is offered three times per year and is free to UCI faculty, staff, and students.

UCI's **W.SparkSBIR**'s mission is to increase women participation and success in SBIR/STTR grants, which are funding dollars for research and development with the end goal of commercialization. W.SparkSBIR puts on women-focused workshops and events geared towards supporting women who want to establish small businesses that advance technologies for the public good.

D. UNIVERSITY OF PITTSBURGH

IMWEL will leverage the four operating units of Pitt's **Office of Innovation and Entrepreneurship (OIE)**. The **Innovation Institute** led by the Vice Chancellor for Innovation and Entrepreneurship, coordinates with partners across the university as well as external partners to launch innovations into the world through licensing and formation of startups. It also provides programs, services and funding needed to assess commercial potential of innovation or big ideas and accelerate the path to market. Similarly, the **Big Idea Center**, established in 2018, is an on-campus, inclusive innovation catalyst to develop the innovative and entrepreneurial skills of the Pitt student community. The **Office of Industry and Economic Partnerships** serves as a one-stop-shop for industry and venture capital firms seeking to partner with Pitt. The team works closely with Pitt's industry partners to understand their interests, connect them with experts across campus, and facilitate the initiations and management of mutually beneficial partnerships. Finally, the **Institute for Entrepreneurial Excellence** serves businesses throughout western Pennsylvania through a mix of consulting, education, and networking opportunities.

5. ENGINEERING WORKFORCE DEVELOPMENT AND DIVERSITY & CULTURE OF INCLUSION RESOURCES

A. COLUMBIA UNIVERSITY

IMWEL will leverage the Engineering School's long-standing **Outreach Programs Office**. Its mission is to "provide greater accessibility to academic and professional opportunities in science, technology, engineering, and mathematics (STEM) disciplines, especially for traditionally underrepresented local stakeholders. Through community engagement, we enhance the quality and reach of learning at all levels." The Outreach Office's full-time staff of three offers programs connecting local K-12 students and educators with the world-class STEM resources at Columbia Engineering, including on-campus and in-school education and enrichment opportunities. In particular, the Outreach Office will support IMWEL's REU and RET programs, and connect to local middle-schools for IMWEL's middle-school interventions described in Narrative Section 5.

B. EAST CAROLINA UNIVERSITY

IMWEL will work with ECU's **Center for STEM Education**. Their mission is to improve the quality and quantity of K-12 teachers of science and mathematics, provide strong experiences in science and mathematics for all K-16 students while increasing the number of graduates pursuing careers in STEM disciplines, create a supportive environment for multidisciplinary research, evaluation, and assessment while bridging the gap between educators and STEM professionals, and encourage community engagement that leads to increased university partnerships with school districts, business and industry, and the community.

The mission of **First Generation Pirates** is to support first generation college students through programs and services designed to support and connect them with campus resources, by creating networking opportunities with faculty, staff and peers, fostering community, and promoting academic and personal success. About 35% of ECU's freshman class qualifies as first-generation. In April 2021, ECU was named to the 2021-22 class of First-gen Forward, the

nation's first recognition program acknowledging higher education institutions for their commitment to first-generation student success.

C. UNIVERSITY OF CALIFORNIA, IRVINE

UCI, a member of the American Association of Universities, is designated by the U.S. Department of Education as a Hispanic-serving institution (HSI) and as an Asian American and Native American Pacific Islander-serving institution. The HSI designation helps the University support first-generation and low income students with federal funding that is used, in part, to boost student financial aid and other student services. Currently, more than 26% of UCI's undergraduate students are Hispanic. These large Hispanic student enrollments will help ensure that we are able to recruit undergraduate students for this project who will serve as the program's participants.

Office of Access and Inclusion (OAI): The Office of Access and Inclusion is a joint office in the Samueli School of Engineering and Donald Bren School of Information and Computer Sciences that facilitates the recruitment, retention, and graduation of undergraduate and graduate students from historically excluded populations underrepresented in computing and engineering. With three full-time staff members, this office supports over 3,000 undergraduate and graduate students through student success programs, educational workshops, and community building activities. These populations include, but are not limited to students of color, women, veterans, students with disabilities, first-generation college students, and students from low-income backgrounds. OAI is a 1,300 sq ft suite with office space and a modernized student study room. Through these initiatives, OAI provides access to computing and engineering pathways and cultivates a welcoming and supportive environment that respects and embraces diversity and individual differences.

OAI resources for graduate students:

- **Engineering DECADE Student Council:** Under the supervision of OAI and DECADE faculty mentors, this is a student-led council comprised of graduate students from underrepresented backgrounds in computing and engineering and students interested in increasing the success of computing and engineering doctoral students from underrepresented groups. Graduate students work together to improve recruitment, retention, and completion of students from underrepresented groups in doctoral programs. Members of the council participate in: 1) recruitment events at national diversity conferences and the California Forums for Diversity in Graduate Education; 2) peer mentoring program; 3) networking events that offer a community to support and provide resources for graduate students from diverse backgrounds; 4) academic and career development workshops; and 5) outreach activities at local k-12 schools.
- **Peer Mentoring Program:** This program offers new students support, guidance, and encouragement during their first year of graduate school. Incoming graduate students from diverse backgrounds are matched with an advanced-level doctoral student who shares their research interests during the summer before their first quarter at UCI. Most of the mentors are students on the DECADE Student Council, so the incoming students are able to get a diverse student's perspective about how to navigate the doctoral program, interact with faculty advisors, and how to take advantage of campus resources. Through the peer mentoring program, mentees and mentors meet one-on-one at least once a month during their first year of graduate school.
- **Academic and Career Development Workshops:** Graduate students have access to quarterly workshops on topics such as, successfully navigating the doctoral journey; academic and nonacademic career paths with doctorate degrees in computing and engineering; job search preparation; and preparing external fellowship proposals for the NSF Graduate Research Fellowship Program and diversity fellowships such as the

GEM Consortium and Ford Predoctoral Fellowship. All of these workshops typically have Engineering DECADE faculty mentors and Ph.D. alumni as speakers and workshop facilitators.

D. UNIVERSITY OF PITTSBURGH

The Swanson School of Engineering (SSOE) **Office of Diversity** views diversity as the integrated differences and similarities that all individuals and programs contribute to the academic mission of the school. The mission of the Engineering Office of Diversity (EOD) is to create and sustain learning and working environments where those differences and similarities are valued and respected, and all students, especially women and underrepresented students are included and empowered to excel in engineering education. EOD provides comprehensive and continuous academic and community support services through a variety of signature program areas: Pre-college Diversity (INVESTING NOW) is designed to prepare students from local high schools for college, especially for matriculation at the University of Pittsburgh; the undergraduate diversity program (PITT EXCEL) is designed to provide students access to academic counseling, peer mentoring, tutoring, engineering research, graduate school preparation and career development workshops, as well as a two-week intensive study skills, math and science review session for pre-freshmen. The other initiative by EOD is the Graduate Engineering (DGE) program for the identification, preparation, recruitment and retention and ultimate PhD production of an increased number of women and underrepresented minority students.

The Engineering Office of Diversity is very unique in its approach to diversity, inclusion, and equity issues, with a holistic **Diversity Management Program (DMP)** plan that integrates a series of diversity education activities, workshops and seminars to create a healthy awareness of the University, school and nation's diversity and inclusion goals and to foster intercultural sensitivity and a positive non-discriminatory workplace, learning and teaching climate in an inclusive engineering community.

The mission of the pre-college **Investing Now** (formerly known as PECAP) program is to provide academic enrichment support to high school students, especially from underrepresented groups, to academically enrich their preparation for science, technology, engineering and mathematic (STEM) education, and provide them access to enrollment at the University of Pittsburgh or engineering school of their choice.

The **Pitt EXCEL** undergraduate diversity program's primary mission is to provide support services and a positive community which will increase the enrollment, retention and ultimate graduation of economically disadvantaged and underrepresented student (URS) groups in the Swanson School of Engineering.

The **Diversity Graduate Engineering Program (DGEP)** is designed to identify and recruit traditionally underrepresented students into Pitt graduate engineering programs through partnerships with student organizations, recruitment fairs and events, visits to other universities and colleges, graduate research experience, and diversity graduate fellowships and scholarships. DGEP focuses on developing and implementing the multi-campus and program partnership for URS access into PhD programs by building bridges between a PhD granting institution and multiple graduate pipeline programs and non-PhD granting institutions and creating a graduate student-centered community to increase URM STEM PhDs.

There are many advantages for choosing to study engineering at the University of Pittsburgh: EOD is unique in how it provides comprehensive support to URS from pre-college through graduate school "under one roof" in an inclusive and respectful academic community. The

Swanson School of Engineering has had measurable success in its diversity efforts for over 35 years. Today, the school is moving their success to a new height with expanded programs for engineering excellence. Through its diversity education initiatives, more than 85% of the students in the Swanson School of Engineering agree that the academic environment is positive and multi-culturally sensitive. EOD is a recipient of the Chancellor's Affirmative Action Award for instituting a cutting-edge diversity vision that carried the school into the new millennium.

The Swanson School of Engineering is a place where students are trained to be global leaders for today and tomorrow, from freshman to graduate and professional careers.

IMWEL will be working with University of Pittsburgh's **Internship Prep Program (IPP)**. IPP is a combination of workshops and individual appointments designed to offer individualized support of each student's internship or experiential learning search. Students who complete the Internship Prep Program and related requirements are guaranteed resources and personalized support while pursuing internships or other experiential learning opportunities during their undergraduate career.

Some of these workshops include:

1. D.I.Y. Resumes: Equips you with the skills to build and maintain a resume over the course of your career.
2. Cover Letter Construction: Have you ever skipped applying for a job because a cover letter was required? Have no fear, we'll teach you the basics.
3. LinkedIn Learning: Have a LinkedIn account, but don't know what to do with it? Stop by for tips and tricks on navigating the world's largest networking platform while also building essential skills employers want to see.
4. Searching Strategies: Not all search engines are created equal... Learn where to start, understand how to search for internships and what will help yield your best results.
5. Networking Necessities: Networking is more than just connecting on LinkedIn and collecting business cards. Join us to learn how to make great first impressions and to build strategic connections.
6. Interview Essentials: In Part 1 of our interview series, learn everything you need to know and do before, during and after your interview.
7. Ace Your Interview Questions: In Part 2 of our interview series, learn how to utilize the STAR method to give the best answers to interview questions, or the greatest weakness could be revealed.

6. COMMUNICATIONS AND DATA STORAGE

IMWEL will take advantage of Columbia's communications tools including:

LabArchives is a web-based electronic laboratory notebook application designed for researchers to organize and share their research data with colleagues. It features version control, providing clear evidence of work completion and authorship; data storage and security via cloud storage on a network of redundant servers; and tools that enable compliance with the data management requirements of funding agencies.

Academic Commons is a publicly accessible digital repository that provides open, persistent access to research produced at Columbia University. Columbia University Libraries manages

Academic Commons as part of the Libraries' long-term digital storage system, which ensures that files are replicated and stored in at least two distinct locations. The repository follows FAIR data principles and uses unique, persistent identifiers and rich metadata to enhance the accessibility of each work.

In addition, the slim silver lining of COVID is that Universities have upgraded their facilities and communications infrastructure to support physically distanced communications, and the four core academic partners are no exception. In addition, researchers have done crash course skills building with all kinds of communications tools, many of which IMWEL has deployed in the process of preparing this proposal, including SLAC, Google Docs, and the omnipresent zoom.

7. OTHER RESOURCES: IMWEL Partners

1. MEMBER ORGANIZATIONS

A. Alydia Health/Organon

Alydia Health is the proud developer of the Jada System, a new device to control postpartum hemorrhage. Their mission is to make childbirth safer for all mothers. Being acquired by Merck (2021), they will become part of Merck spin-off company Organon. About Organon - fueled by its leading contraceptives and fertility businesses, Organon will invest in innovations that support the distinct health care needs of women today. Organon will also focus on its important biosimilars business, focusing on oncology and inflammatory diseases, while also maximizing the value of its trusted dermatology, pain, respiratory and cardiovascular portfolio in countries around the world where there is still great need for these treatments.

B. NextGenJane

NextGenJane is a start-up company using tampons as a collection device to study menstrual blood and cervical vaginal fluid.

C. Pregnolia AG

Pregnolia AG is a Swiss-based start-up company developing a tool to measure cervical stiffness for better prediction of preterm birth.

D. Renovia

Renovia was formed to provide products for better first-line diagnosis and treatment to improve the condition-specific quality-of-life for millions of women with pelvic floor disorders.

E. Viscus Biologics

Viscus Biologics brings innovative biologic platforms to market and supports the research and development of custom biologic products for our customers. Viscus Biologics utilizes an Original Design Services Model, similar to outsourced medical device design firms except that our core competency is in the design, manipulation, manufacture, and marketing of human or animal tissue for biomedical applications.

2. COLLABORATION PARTNERS

A. Alexandria Launchlabs

Alexandria LaunchLabs is the premier startup platform for early-stage life science and agtech companies. Alexandria LaunchLabs provides move-in-ready office/laboratory space, shared equipment and services, creative amenities, access to startup capital through the Alexandria Seed Capital Platform, and engagement with Alexandria's world-class network.

B. Deerfield Catalyst

Deerfield Catalyst is a premier medtech incubator founded to develop transformational medtech solutions that improve outcomes and streamline patient care.

C. Harlem Biospace

Harlem Biospace is a new biotech incubator, the first of its kind in New York City, to offer affordable shared wet-lab space for early-stage biotech companies.

D. HITLAB

HITLAB is a digital health company in NYC (located by CUIMC in Lasker), that hosts a women's health tech challenge.

E. The Iris Fund

The Iris Fund works to understand what causes labor in a full-term pregnancy so that we can eventually stop labor from starting early – preventing preterm birth. Since its founding in 2018, it has raised over \$200,000 from more than 450 donations from a diverse and expanding network including private individuals, family foundations and corporate partners. Its goal is to build the infrastructure to deliver \$5-10M over the next five years.

F. Materna Medical

In 2018, Materna Medical launched Milli, the first expanding vaginal dilator to address pelvic pain in the general population. In addition, we are conducting a clinical trial for Materna Prep, a device to be used during the first stage of labor to expedite delivery and reduce the incidence of internal damage to the mother's pelvic region.

G. MSquared Associates

MSquared Associates is a regulatory consultant for medical devices, works with BiomedX.

H. NYSTAR / EMPIRE STATE DEVELOPMENT

Empire State Development's Division of Science, Technology and Innovation (NYSTAR) programs and centers emphasize the importance of working with industry as a way to leverage New York State's technology strengths to produce new products.

I. OCSTEM

OC STEM Initiative strengthens the workforce pipeline throughout Orange County by promoting competencies in science, technology, engineering and mathematics (STEM) from cradle to career through a collaborative network of public and private partnerships.

J. Upstate Capitol Association of NY

Since 2003, the Upstate Capital Association of New York has been the place to meet capital providers - early stage, venture, growth and private equity investors - as well as lenders, professional advisors, entrepreneurs and company executives - who are making investments in companies across New York

3. CONSULTANTS

A. Ellen Casey, Hospital for Special Surgery

Dr. Ellen Casey is an Associate Attending Physiatrist in the Department of Physiatry and the Women's Sports Medicine Center at the Hospital for Special Surgery. Dr. Casey's clinical practice focuses on the conservative treatment of acute sports medicine injuries and spine disorders. She has particular expertise in the female athlete, including the female athlete triad, stress fractures and physical activity during and after pregnancy. She is skilled in fluoroscopically-guided spine injections and ultrasound-guided peripheral joint and soft tissue injections. Dr. Ellen Casey will assist in the Healthy Aging testbed as outlined in the project description.

B. Sherry Liu, University of Pennsylvania

Dr. Sherry Liu is an Associate Professor for Bioengineering and Orthopaedic Surgery in the University of Pennsylvania. Dr. Liu's research focuses on biological processes in bone and on how they influence bone material, microstructural, and biomechanical properties with aging, disease, and therapies. Dr. Liu utilizes state-of-the-art imaging, image analysis, and mechanical modeling techniques to explore the mechanisms affecting mechanical functions of skeletons at different length scales in both animal models and clinical

investigations. Dr. Sherry Liu will assist in the Healthy Aging testbed as outlined in the project description.

C. Center for Research in Education and Social Policy, The University of Delaware

The Center for Research in Education and Social Policy (CRESP) will serve as the evaluator of the IMWEL ERC; Dr. Sue Giancola from CRESP will lead and coordinate evaluation efforts. Dr. Giancola has a PhD in Policy Research, Evaluation, and Measurement from the University of Pennsylvania, as well as degrees in management and engineering. With over 25 years of experience, she has evaluated large-scale projects funded through the NIH, NSF, U.S. Department of Health and Human Services, and U.S. Department of Education. Additional information on the scope of work is provided in Section 8. Evaluation Plan within the project description.

**Please note that Institutional Letters of Commitment for IMWEL Headquarters have been uploaded as Supplementary Documents.*