NEWS AND RESEARCH:
FERGUSON LABORATORY FOR ORTHOPAEDIC AND SPINE RESEARCH

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EXPANDING THE BOUNDARIES OF BASIC SCIENCE AND CLINICAL SPINE RESEARCH



Ferguson Lab Expanding the Use of Human Tissue Models in Spine and Musculoskeletal Research

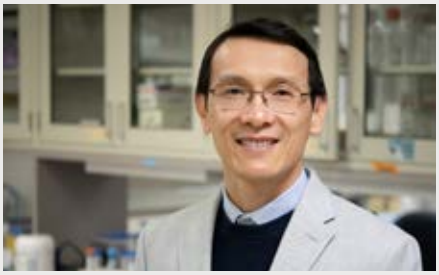
The Ferguson Laboratory for Orthopaedic and Spine Research has been using human derived cells and tissues for years to study the basic biology of spine degeneration and chronic low back pain, among other lines of investigation. Access to the growing Bethel Musculoskeletal Research Center (BMRC) Biobank is now allowing the laboratory to expand its research options utilizing multiple human musculoskeletal tissues for tissue explants, organoids, bioreactors, and other experimental model systems.

These expanded options for using human tissues in research coincides with greater emphasis from the National Institutes of Health on incorporating human-derived models into biomedical research. Within the Ferguson Laboratory, the shift provides flexibility as well as an opportunity to develop more human-relevant models while continuing to use animal models for questions that require an intact biological system or which simply cannot be done in human tissues or in human clinical studies.

Understanding the Limits of Any Type of Experimental Model

Animal models have long allowed scientists to investigate disease mechanisms and evaluate potential interventions before they can be studied in people. However, a biological pathway or finding identified in an animal model may resemble but not precisely reproduce the corresponding pathway in humans. Those differences can contribute to the failure of drugs and other interventions when they move from preclinical studies into human trials.

"Animal models can bring us closer to understanding a disease process, but they may not bring us close enough," says



Nam Vo, PhD, professor of orthopaedic surgery and co-director of the Ferguson Laboratory. "A study can identify something important in an animal and still lack additional information needed to understand what will happen in a person."

Biological variation among people introduces further complexity. Patients with the same diagnosis may differ in their genetics, tissue biology, environmental exposures, and other sociopsycho characteristics that influence disease progression and treatment response. Human-derived models give scientists another way to investigate some of these differences using cells and tissues obtained directly from patients.

The greater emphasis on human-derived models should not be interpreted as evidence that animal studies are no longer needed. Human cell cultures, explants, organoids, and bioreactors each reproduce selected elements of human biology, but none recreates an entire person. Questions involving systemic physiology, immune responses, metabolism, or interactions among multiple organs may still require an animal model.

"The goal should be to determine which model is appropriate for each scientific question," Dr. Vo says. "Many projects will benefit from combining several models so that the strengths of one compensate for the limitations of another."

Expanding Access to Human Musculoskeletal Tissue

The Ferguson Laboratory has used intervertebral disc tissue collected during surgery for a number of years. Lab staff isolate cells from the tissue, expand them in culture, and use them to examine cellular processes associated with spine degeneration. The laboratory also derives cells from ligamentum flavum surgical specimens.

The BMRC Biobank provides a more extensive and systematic source of human musculoskeletal tissue. Established procedures govern patient consent, collection in the operating room, transport, processing, preservation, specimen tracking, and research access. The proximity of UPMC operating rooms, the Biobank, and Pitt research laboratories also allows specimens to be transferred and processed promptly, including when studies require fresh tissues or viable cells.

That infrastructure addresses an obstacle faced by scientists at institutions where surgical services and research laboratories are separated by considerable distance or where no coordinated tissue collection process exists. It also gives the Ferguson Laboratory access to several tissue types needed to construct models that extend beyond an isolated population of, for example, intervertebral disc cells.

Studying Interactions Among Spine Tissues

The Ferguson Laboratory is working toward organoid and bioreactor approaches that incorporate human cells

continued >

Ferguson Lab Expanding the Use of Human Tissue *(continued)*

derived from several components of the spine. These include the intervertebral disc, paraspinal muscle, vertebral bone, and ligamentum flavum.

"We are trying to design a chip that allows us to grow cells from those different tissues together and study how they interact," Dr. Vo says. "These are all human cells. Without the BMRC Biobank and access to the different orthopaedic tissues, developing that type of model would be very difficult."

A culture containing disc cells alone can reveal how those cells respond to a defined stimulus. It cannot show whether signals originating in muscle, bone, or ligament tissue alter that response. The model would still reproduce only selected features of the spine. It would not contain the complete vascular, neurological, immune, and mechanical environment found in a person. Instead, it would provide an important intermediate model between isolated cell culture and whole-organism research, allowing the laboratory to study interactions that single-tissue models cannot capture.

Connecting Specimens With Clinical and Molecular Data

The BMRC Biobank also permits several forms of analysis beyond cell culture. Fresh tissue can provide viable cells, while frozen specimens can support subsequent molecular studies. Paraffin-embedded tissue can be used for histology and other imaging-based analyses. Genomic, epigenomic, proteomic, and other multiomic methods can add further information about the biological characteristics of each specimen.

Those findings can then be evaluated alongside data from the patient. Relevant information may include MRI examinations, radiographs, clinical history, treatments, and longitudinal outcomes documented in the electronic health record.

"No individual dataset provides the entire answer," Dr. Vo says. "Imaging shows structural characteristics. The electronic health record provides clinical history, diagnoses, treatments, and outcomes. Tissue analyses reveal cellular and molecular features."

Integrating these sources may help the Ferguson Laboratory investigate why patients with apparently similar clinical presentations follow different courses. Two patients with chronic low back pain may have different underlying biological processes, rates of progression, or responses to treatment. As these datasets grow, machine-learning methods may help identify combinations of biological, imaging, and clinical characteristics associated with disease trajectory or recovery.

Using Animal Tissues More Efficiently

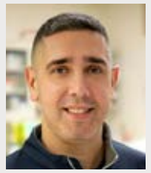
Greater use of human specimens also raises a related question: how can institutions use animal models more efficiently when they are necessary for specific research projects or needs?

A laboratory studying one organ or tissue may collect that material and discard the rest. That is inefficient at best and wasteful at its worst. This is particularly consequential with aged animals, which require substantial time and expense to maintain. Dr. Vo previously led an aging working group at Pitt that coordinated tissue collection among laboratories. When aged models were used, participating laboratories collected different tissues from the same animals, making the most efficient use of an expensive research asset.

"It is not only a matter of reducing the use of animals," Dr. Vo says. "We also need to use them more effectively in a collaborative and integrated manner. It becomes a matter of conducting the best science possible while optimally managing the resources at your disposal. It's about effective stewardship, ethical principles, and the responsible use of using living organisms for scientific discovery."

Ferguson Lab Profile: Paulo Coelho, MS, MBA

Laboratory Manager and Director of the BMRC Biobank



Since January 2026, **Paulo Coelho, MS, MBA**, has served as the director of the Bethel Musculoskeletal Research Center (BMRC) Biobank, which was launched in October 2024 to accelerate the discovery of biomarkers and therapeutic targets for musculoskeletal conditions and enhance patient outcomes through more personalized orthopaedic treatments.

Previously, he served as the laboratory manager of the Ferguson Laboratory for Orthopaedic and Spine Research where he managed daily laboratory operations, supported grants associated with the lab's research, including its current work funded through the National Institutes of Health's Helping to End Addiction Long-term (HEAL) Initiative, and coordinated resources and workflows across multidisciplinary research groups investigating a range of spinal conditions.

Mr. Coelho first joined the Ferguson Laboratory as a research technician in 2006. His progression from the laboratory bench to managing large-scale research and biobanking efforts reflects the scientific and operational expertise he has developed within the laboratory, as well as across Pitt's other labs and the greater University of Pittsburgh ecosystem, which strives to cultivate great talent from within.

Originally from Portugal, Mr. Coelho came to the United States to study chemistry at the University of Miami on a scholarship to play for the university's Division I basketball team. He earned his bachelor's degree in 2003 and then earned a Master's degree in biomedical sciences from Barry University in 2005 before moving to Pittsburgh.

A Serendipitous Meeting Led to a Career at Pitt

How Mr. Coelho found and first ended up at the Ferguson Lab is an interesting story of a chance encounter.

"My first connection to the lab and Dr. Sowa happened in an unexpected way," Mr. Coelho says. "After moving to Pittsburgh where my wife is originally from, I received my work permit and I took a job at a retail store in the area. As it turned out, Dr. Sowa's (**Gwendolyn Sowa, MD, PhD**, chair, Department of Physical Medicine and Rehabilitation and co-director, Ferguson Laboratory) mother was the store manager. She learned that I had a background in chemistry and biomedical sciences and mentioned me to her daughter, who at the time had recently joined UPMC and the University of Pittsburgh. Dr. Sowa and I spoke several times, and she hired me as a research technician in her lab. I believe I was one of her first hires at Pitt and certainly one of the early members of her research lab."

Developing at the Laboratory Bench

Mr. Coelho's initial work as a research technician in Dr. Sowa's lab involved experiments that examined the effects of mechanical stress on spinal cells. The laboratory used compression chambers and flexible culture plates that allowed cells to be compressed or stretched under different conditions. PCR analyses then showed how gene expression changed in response to the duration and intensity of those mechanical forces, linking cellular experiments to the physical forces acting on the human spine. He also handled tissue specimens obtained from orthopaedic operating rooms, gaining early experience handling and managing biological materials, which is now a core of his daily work as the BMRC Biobank director.

After several years working as a research technician, Mr. Coelho advanced to laboratory manager as Dr. Sowa's research activities expanded. The new role moved him beyond responsibility for his own experiments. He began supporting medical students, summer research students, international postdoctoral researchers, UPMC residents, physicians, and faculty members working on different projects in the lab.

"As a lab manager, you become the glue or connective tissue among many different people," Mr. Coelho says. "You need a general understanding of what everyone is working on, where they are in the process, and how you can help them move their research forward."

Adding the Operational Side of Science

The lab manager role also gave Mr. Coelho exposure to the other sides of conducting research in a busy lab: budgets, personnel, compliance requirements, and the operational systems underlying scientific research at a large, interconnected academic medical center. Although he continued to enjoy bench work, Mr. Coelho became increasingly interested in how those components functioned within institutions as large as Pitt and UPMC.

"I enjoyed the bench science and still do, but I also became interested in running laboratory budgets and the operational and business side of science," Mr. Coelho says. "It's a very different aspect of conducting research, but it's essential to keeping those projects moving forward."

To pursue this interest, Mr. Coelho earned an MBA in finance from the University of Pittsburgh in 2014.

"The conventional opportunities for advancement in bench science are often tied to earning a PhD. I was considering what other paths I could follow, and I also had an interest in finance and capital markets," Mr. Coelho says. "An MBA gave me a way to develop those interests and determine how I could combine them with my scientific background. Dr. Sowa was very supportive. She gave me the flexibility to attend courses that were important to my training while still working in the lab."

Coordinating the LB^{3}P Project

The NIH-funded Low Back Pain Biological, Biomechanical, and Behavioral Phenotypes (LB^{3}P)* project in the Ferguson Lab enrolled more than 1,300 participants over five years. Its size and multidisciplinary structure created scientific, administrative, and biospecimen-management demands distributed across several departments.

As part of the LB^{3}P project, Mr. Coelho was responsible for specimens entering the laboratory. He implemented an existing Pitt-UPMC system that recorded the specimens in a database, tracked their physical locations in laboratory freezers, and linked them to the corresponding participant information.

The project required the same ability to connect people and resources that Mr. Coelho had developed as laboratory manager, now applied across a large clinical cohort. He is currently helping to manage the LB^{3}P five-year follow-up study, which, like the original project, is funded through the NIH HEAL Initiative.

"The five-year follow-up allows us to evaluate how participants have changed since their initial assessments. The value of the original collection increases when we can connect baseline biological, biomechanical, behavioral, imaging, and clinical information with what happens to each participant over time," Mr. Coelho says.

Extending Research Experience Into the BMRC Biobank

When plans emerged for a musculoskeletal biobank within the Bethel Musculoskeletal Research Center, Mr. Coelho recognized that his work in the Ferguson Lab had prepared him for many of its operational demands.

"This is what I had done for more than a thousand people in the LB^{3}P study, so I wanted to see what it would look like at a larger scale and with a larger impact," Mr. Coelho says.

Mr. Coelho approached Ferguson Lab Clinical Director and BMRC Executive Director, **Joon Y. Lee, MD**, and proposed that he could help develop the Biobank while continuing to support the efforts of the Ferguson Lab. Mr. Coelho's initial work with the BMRC Biobank helped establish the specimen workflows, database and storage systems, and website functions, including a new iteration of the website that launched in June 2026, which features a real-time inventory summary of available data and surgical collections as they proceed. That work led to his appointment as the Biobank's director.

"I have enjoyed each stage of the work I've done at Pitt for the last 20 years," Mr. Coelho says "I enjoyed conducting experiments at the bench. I appreciated becoming the person who could connect students, residents, postdoctoral researchers, physicians, and faculty members within the laboratory. The MBA allowed me to add financial and operational knowledge. LB^{3}P and the BMRC Biobank have given me opportunities to apply all of those skills to projects with much greater scale."

**The University of Pittsburgh Low Back Pain: Biological, Biomechanical, Behavioral Phenotypes (LB^{3}P) Mechanistic Center of the Back Pain Consortium Research Program (BACPAC), part of the National Institutes of Health Helping to End Addiction Long-term Initiative administered by the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS) of the National Institutes of Health (NIH).*

For specimen access, contract inquiries, feasibility questions, or media and philanthropic partnerships, email the BMRC Biobank team at biobank.bethel@pitt.edu.

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ABOUT THE FERGUSON LABORATORY FOR ORTHOPAEDIC AND SPINE RESEARCH



The Ferguson Laboratory for Orthopaedic and Spine Research at the University of Pittsburgh studies the complex developmental mechanisms, etiologies, and basic biology behind intervertebral disc degeneration (IDD), and it works to develop biological, biomechanical, and cell-based therapies for IDD. Another major endeavor of the Ferguson research program is studying the deep phenotype of chronic low back pain through collection and processing of large patient datasets. Leading the laboratory's multidisciplinary research efforts are co-directors Joon Y. Lee, MD, FAOA; Gwendolyn A. Sowa, MD, PhD; and Nam V. Vo, PhD.

The Ferguson Laboratory explores distinct but complementary research areas to dissect and clarify the physiological processes that lead to disc degeneration. Dr. Vo leads the lab's efforts studying the contribution of aging on IDD and loss of disc extracellular matrix (ECM) proteoglycans, with a special focus on cellular senescence and autophagy in regulating aggrecan homeostasis. Dr. Sowa oversees investigations involving the mechanisms of mechanical strain on disc cell metabolism, with an emphasis on how mechanical strain-induced inflammation controls ECM collagen expression and breakdown. As a practicing orthopaedic surgeon, Dr. Lee explores minimally invasive treatment of trauma and conditions in the spine.

The lab is named in honor of Albert B. Ferguson Jr., who held the Silver Chair of Orthopaedic Surgery at the University of Pittsburgh from 1953 until his retirement in 1986. Dr. Ferguson was a visionary force behind the evolution and growth of the clinical, research, and training programs of the University of Pittsburgh Department of Orthopaedic Surgery into the internationally respected program of excellence it is today

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