Areas of Specialization

A central goal of the program is to capitalize on the highly interdisciplinary nature of UCSF and create an academic program that integrates multiple disciplines. PhD students will have the opportunity to participate in specialized training in areas that will ensure distinction of the PhD program at UCSF. These specialized areas include:

Musculoskeletal Biomechanics

Musculoskeletal Biomechanics is one of the foundational sciences of physical therapy and rehabilitation science. Motion analysis and applied biomechanics have roots from over a century ago; however, with recent advances in technology, new and innovative ways to assess and record human movement are being developed. Furthermore, reduction in costs for some biomechanics research methods is resulting in larger numbers of laboratories performing these investigations. The result has been an explosion in high-quality biomechanics research performed across the country and beyond. These discoveries are being translated immediately to the clinic for improved patient care.

Within this specialization, we train new investigators on the latest advancements in musculoskeletal biomechanics and prepare them for careers in research in academia and industry. General areas of study in the Musculoskeletal Biomechanics track include:

- assessment of normal and pathological human movement using motion analysis and kinematic imaging techniques, and
- quantitative imaging of the musculoskeletal system, including advanced quantitative
magnetic resonance imaging (MRI), spiral computed tomography (CT), high-resolution peripheral quantitative computed tomography (HRpqCT), and Positron Emission Tomography (PET).

The UCSF Human Performance Center [1] is a state-of-the-art motion analysis laboratory with a 10-camera VICON optical motion capture system and three AMTI force platforms for measurement of ground reaction forces. This laboratory, which is dedicated to research, is the only active motion capture system at UCSF. The UCSF Musculoskeletal Quantitative Imaging Research [2] (MQIR) group is a large group of interdisciplinary researchers dedicated to advancing quantitative imaging for clinical implementation and development of post-processing and training procedures for research and clinical use. This group has access to two 3T research-dedicated MR scanners, one whole-body 7T MRI scanner, HRpqCT, CT, PET, PET-MR, and micro-CT scanners. This infrastructure and network of expertise, in combination with the patient population at UCSF, creates an ideal environment for training research scientists in the area of musculoskeletal biomechanics and rehabilitation science.

Clinically Informed Neuroscience

The field of neurorehabilitation has made significant advances over the past two decades in developing metrics to assess functionality and applying these metrics to treatment paradigms. Despite this progress, we have yet to fully appreciate the guiding principles underlying activity-based neuroplasticity and restoration of function. The ability to transform how rehabilitation is implemented in the clinic is dependent upon defining these basic principles in the context models of neurotrauma, neuroinflammation, and neurodegenerative disease, with an emphasis on the translation of these laboratory findings to the clinical arena.

The Clinically Informed Neuroscience track offers two pathways of investigation.

- The first pathway is invested in a clinically-based platform, which focuses on neural injury and neurodegenerative disease, with the objectives of assessing disability, applying new technologies to improve functionality, and testing the underlying basis of activity-based restoration of function and outcomes research. To achieve these objectives, students have access to state-of-the art motion analysis; robotics, including lower extremity exoskeletons with biofeedback to support locomotion; specialized equipment such as the G-trainer by Alter G, an anti-gravity treadmill to support learning-based training; and the motion analysis equipment in the PT Movement Research Laboratory at San Francisco State University. Students have the opportunity to interrogate the functionality of the brain and neuroplasticity through state-of-the art MRI-based technologies and transmagnetic stimulation in the Departments of Radiology and
Biomedical Imaging and Neurology, which oversees a rich patient database for stroke and multiple sclerosis for outcomes research. In addition, the Department of Physical Therapy at SFSU provides students with opportunities to participate in research on balance-based torso weighting interventions for patients with multiple sclerosis and a recently developed program to study movement accuracy. Access to the UCSF patient population, through the collaborative departmental efforts of Physical Therapy and Rehabilitation Science, Neurology and Neurological Surgery, position students’ science at the forefront of clinical care.

- The second pathway within the Clinically Informed Neuroscience track is devoted to laboratory-based translational research that focuses on experimental models of neurodegeneration and chronic neuroinflammation and the interplay between defined activity and key molecular events driving motor, sensory and cognitive decline or recovery. This pathway is supported by laboratories uniquely positioned to study structure and function and the molecular basis for damage and reparative processes. These laboratories combine high-level imaging microscopes with molecular biology platforms to study structure and function. Essential to this research is the Neurobehavioral Core for Rehabilitation Research, a facility operated by the Department of Physical Therapy and Rehabilitation Science that provides state-of-the art instrumentation to fully profile motor, sensory and cognitive function and assess voluntary or forced activity in the context of disease-based animal models. The Core not only provides ample opportunity for students to measure neurological function, but also to address activity as a determinant of outcome. Additional support for this pathway comes from UCSF-sponsored Core services, including: 1) the Biological Imaging Developmental Center that provides instrumentation for novel imaging, including spinning disk confocal microscopy and confocal microscopy with capability for multi-color and spectral imaging, 2) the Parnassus Flow Cytometry Core, and 3) the Mouse Genetics Core, operated by the Diabetes Center. This pathway will interface with the graduate programs in Neuroscience, Biomedical Sciences and Stem Cell Biology. Students have the opportunity to attend classes and seminars within these programs including mini-courses that are uniquely tailored to specific research topics.

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**Chronic Pain**

Falling between the Musculoskeletal Biomechanics track and the Clinically Informed Neuroscience track is the cross-cutting field of chronic pain. UCSF has a strong basic science group in the neural underpinnings of pain physiology, housed primarily in the Neuroscience and Biomedical Science graduate programs. There are also strong pre-clinical and clinical programs in the treatment of acute and chronic pain, housed primarily in the Departments of Anatomy, Physiology, Anesthesia, Neurology, Physiological Nursing, and Psychiatry. The Department of Physical Therapy and Rehabilitation Science is a participant in the Center of Excellence in Pain Education [3], and contributes to the case study components of the educational program. Experienced faculty in pain science are faculty in the PhD program in Rehabilitation Science, and this collaboration helps forge research linkages between the basic science laboratories and the clinical care of patients with acute or chronic pain.
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