Why study orthopaedic biomechanics? At one time or another, we are all touched by orthopaedic tissue degeneration or failure. Osteoporosis affects approximately 75 million people in Europe, USA and Japan, where mortality rates are 20-24% within one year of hip fracture and survivors have an increased risk of dying within 5 years. Similarly, osteoarthritis, a degenerative disease of articular cartilage, is the most common cause of disability in the U.S. and affects >10% of our population to an annual societal cost of ~$150 billion. In 2014, the American Academy of Orthopaedic Surgeons estimated that 7.2 million Americans had total knee or hip arthroplasty, or “replacement”, using orthopaedic implants.

While these statistics are sobering, engineers are leading the development of cutting edge treatment options for these and other orthopaedic disorders. In bone, how fragility fracture relates to bone material “quality” is now contributing to development of exciting new therapeutics. Promising regenerative approaches for fracture healing and cartilage degeneration have resulted from advancements in 3D printing and cell-based therapies. And biomimetic and other strategies for self-repair are showing early promising results. But ultimately, these strategies are only successful if they can bear the high physiological loads and perform complex mechanical functions inherent to native tissues.

This course focuses on the mechanical design of organisms with a specific emphasis on the mechanics of the musculoskeletal system. We will apply a multi-scale approach to understand the unique mechanical behaviors and physiological response and adaptation of orthopaedic tissues (e.g., cartilage, bone, tendons and ligaments). In lecture, through individual and group work, and in a semester term project we will emphasize select areas that include mechanical behavior of healthy and diseased tissues; emerging solutions to repair, regenerate, or replace damaged tissues; and case studies in prosthesis design and biomaterials.

By the end of the course, students will be able to:

1) Relate mechanical function to underlying material structure, chemistry, composition, and physiology of bone, cartilage, tendon and ligaments,

2) Apply mechanics of materials concepts to the behavior of these musculoskeletal tissues across nanometer to macroscopic length scales,

3) Describe how musculoskeletal tissues adapt to their mechanical environment,

4) Evaluate engineering interventions to treat musculoskeletal damage and disorders,

5) Integrate engineering concepts with concepts in life-sciences and clinical treatments.

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1 http://www.womens-health-advice.com/photos/osteoarthritis.html
2 EFFO and NOF (1997) Osteoporos Int 7:1