Biomathematics Seminar
Tuesday 11/6/07
Speaker: Sarah Olson

Title: Mathematical Modeling of Cartilage Regeneration

Articular cartilage is a connective tissue that lines the surface of bones in diarthrodial joints (hips, shoulders, and knees). Cartilage covers each end of the bone, and serves to protect these surfaces from impact stresses, and minimize friction and wear in the joint. A structural extracellular matrix (ECM), consisting largely of water, as well as collagen, glycosaminoglycan (GAG), and other proteins, surrounds the cells in cartilage (chondrocytes). Aging and osteoarthritis can lead to degeneration of cartilage ECM, leading to holes or defects and, ultimately, complete tissue degradation resulting in painful bone-on-bone contact necessitating joint replacement. Cartilage has a limited capacity for growth and repair of large defects; therefore biomaterials for defect-filling are being explored. Hydrogels, which are superabsorbent natural or synthetic polymers with flexibility similar to tissues, are being explored to provide a 3-d scaffold for cartilage regeneration. Upon injection into a defect, hydrogels will slowly degrade as cell proliferation and biosynthesis result in turnover of the gel scaffold. Reaction-diffusion models of cartilage regeneration will be presented for an in vitro experiment performed on a tissue explant. In this experiment a cylindrical cartilage explant has a core region cut out and replaced with hydrogel. Models that capture interactions between matrix accumulation (cartilage regeneration), hydrogel degradation and nutrient diffusion are developed for cases of a 1-D radial approximation, as well as an axisymmetric geometry using a level set method . A primary modeling goal is to analyze effects of model parameters on the regeneration time required to replace the hydrogel with cell-synthesized extracellular matrix.