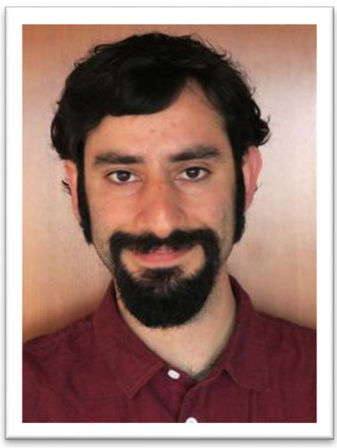
PHYSICAL MATHEMATICS SEMINAR

Adventures in cell herding: engineering and control of living cellular swarms

DANIEL J. COHEN

Princeton University



ABSTRACT:

We are working to accomplish for cells something akin to what a shepherd and sheepdogs bring to flocks of sheep: control over large-scale collective cellular motion. As coordinated cellular motion is foundational to many forms of multicellular life, being able to 'herd' or program large-scale cell migration raises exciting possibilities for accelerated healing, tissue engineering, and novel biomaterials. We treat tissues as living, multi-agent systems allowing us to combine approaches from disparate fields—control theory, active matter mechanics, tissue engineering, and materials—both to better understand the rules of cellular crowds and to build new tools to 'herd' large-scale cell behaviors. One approach we use is guided self-assembly of tissues where we establish precise initial conditions and let the tissues develop spontaneously. Here, we combine machine learning, biomechanical modeling, and tissue engineering to: characterize the rules of collective migration within tissues of different types; connect cell-cell mechanics to large-scale collective dynamics; and build complex 'tissue tessellations' through precise control of healing boundaries between tissues. In contrast to self-assembly, we are also developing tools that allow for true, interactive control of tissue growth and form at the multicellular level. Here, we use a unique bioelectric cue—electrotaxis—to literally program large-scale collective cell migration, enabled by our 'SCHEEPDOG' bioreactor. In this case, ionic currents manipulate cellular signaling allowing interactive control of both cell direction and speed, allowing us to: accelerate 'healing' in vitro; investigate how intrinsic collective behaviors compete with imposed behaviors; and reprogram growth of 3D tissues and organoids.

TUESDAY, MAY 9, 2023
2:30 PM – 3:30 PM
MIT - Building 2, Room 449

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