Hybrid cell-particle aggregates

During the last years, soft matter physics has been applied to studying the biophysics of tissues using cellular aggregates as model systems.[1,2] These studies have led to understanding of tissue rheology, spreading, mechanosensitivity, wetting, adhesion and fracture properties. Cellular aggregates result from aggregation of a few thousands of cells and form spheroids because of intercellular interactions. The aggregates behave analogously to liquid droplets and minimize their surface energy by forming a ball.

While single cell migration has been studied extensively, much less is known about the migration of cell populations. Since aggregate spreading occurs during early embryonic development and is suspected to play a large role in cancer metastasis, the results obtained from such analogies may have important implications in our understanding of both tissue development and cancer.

It has been previously shown that particles can modify the mechanical properties of individual cells in terms of adhesion area, proliferation and motility.[3,4] Recently we have focused on 3D cellular aggregate – particle hybrid systems.[5,6] We propose to study the mechanical properties of aggregates using the **pipette aspiration technique**. In this method (Figure 1) a cellular aggregate is aspirated with a constant negative pressure into a micropipette. The penetration length of the hybrid aggregate into the pipette is observed by optical microscopy and measured as a function of time. Using this method, we obtain the surface tension, elastic modulus and viscosity of aggregates. We have recently assembled a novel micropipette aspiration set up with unprecedented pressure resolution using a piezoelectric pressure controller.

The student will study the cellular aggregate – particle system by varying the size and the volume fraction of the particles in the aggregate. The work will consist of cell culture, making cellular aggregates, and characterization of the saggregates using the pipette aspiration technique (including experiments and data analysis).

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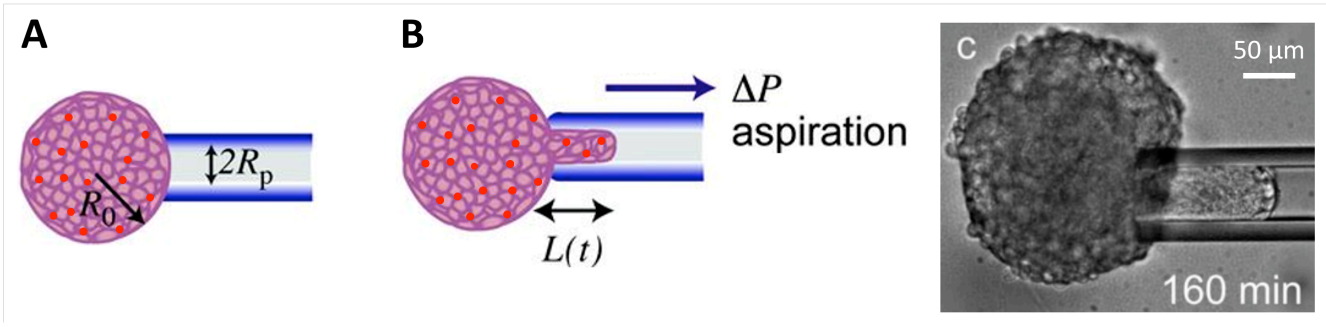

Figure 1. (A, B) Schematics of a hybrid cell – particles aggregate and (C) experiment of a cellular aggregate aspiration inside a micropipette.

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Active particles under motility gradients

The collective motion of active colloidal particles has shown out-of-equilibrium behavior similar to the collective motion of flocking birds, schools of fish and swarming microbes. This summer assignment leads to a Bachelor's thesis or to the completion of a special assignment in the field of collective motion and phase transitions of active particles. The student will investigate behaviour of model active colloids known as Quincke rollers (see figure below) under position-dependent rolling speeds that are generated with electric field gradients in the environment. During the project, the student will learn basics of creating and controlling active colloids and acquire valuable skills in optical microscopy, data acquisition and image analysis. The student is expected to have a good command of Matlab/Python and to be skilled in solving differential equations both analytically and numerically. Experience in finite element method (FEM) calculations is considered as an advantage.

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