Open Ph.D. projects

1.

Announcer: Péter Galajda

Doctoral School: University of Szeged, Faculty of Science and Informatics, Doctoral School of Biology

Title of the research topic: Studying the effect of the microenvironment on single cells and populations using microfluidic devices

Description of the research topic: The microenvironment has a great impact on the life and development of cells. The presence of extracellular chemical signals and factors or possible drugs, as well as interactions with nearby cells influences various biological processes both on the cellular and the population level.

Microfluidic technologies make it possible to create precisely engineered physical, chemical and biological environments for for cells and cellular populations. This opens up the possibility to perform experiments that are impossible to do using traditional methods.

In this research project we study the effect of the physical and (bio)chemical characteristics of the environment on the cellular phenotype, the cell cycle and the population dynamics. Using light microscopy we do detailed single cell level analysis in space and time, and map the heterogeneity and find rare events and phenomena within the population. With this method we plan to study the differentiation and senescence of stem cells, the immune cell response, the morphological characteristics of yeast cells, and the cell cycle and symbiotic function of algae.

2.

Announcer: Péter Galajda

Doctoral School: University of Szeged, Faculty of Science and Informatics, Doctoral School of Biology

Title of the research topic: Studying aging and phenotypic heterogeneity of bacteria using holographic optical tweezers

Description of the research topic: Bacteria reproduce by binary fission after which two seemingly identical daughter cells are produced. This mode of reproduction raises several questions. Without a clear distinction between “parents” and “daughters”, can the concept of “age” applied to bacteria? Are the daughter cells really identical/similar (phenotypically)? How does (phenotypic) variability emerge in a clonal bacterial population? During the project we use a novel experimental platform based on optical trapping and microfluidics to study a growing colony with single cell level of detail for an extended period of time. We track cell elongation and division rate, cell survival, expression levels of proteins and swimming behavior in a constantly dividing population of *E. coli*

bacteria. We expect to see how variability and heterogeneity of these measured parameters develop in a clonal population descended from a single cell.

3.

Announcer: Lóránd Kelemen

Doctoral School: University of Szeged, Faculty of Science and Informatics, Doctoral School of Physics

Title of the research topic: Study of with single cells with indirect optical micromanipulation

Description of the research topic: The optical trap was applied for biological tasks already at its time of birth, and it has been providing important results to science ever since. The trapping of single cells mainly aimed to explore the cells' mechanical characteristics: for instance, the physiologically important deformation of red blood cells in microvessels were modelled with their direct trapping in order to stretch or bend them. The trapping laser beam however, can be easily harmful for the cells through thermal or photolytic processes. Another problem is the relatively weak trapping force due to the small refractive index contrast between the cell and the surrounding water and that the trapping position is ill-defined within the optically inhomogeneous cell. Owing to recent developments, it is possible to trap the cells indirectly, where a properly designed and fabricated microtool is attached to the cell, which is actuated through this trapped tool. This method was developed in our laboratory where we operate all the necessary infrastructure: an optical trap combined with a fluorescent microscope, a microfabrication setup to prepare the microtools and we also have the expertise for the surface activation of these tools. The research topics is the application of the indirect cell manipulation method in two main directions: the first one is the improvement of 3D imaging of cells where cell manipulation is combined with multiview microscopy to observe the cells in their static status (fixed cells) or the observation of dynamic events inside live cells. The other direction is to investigate cell-cell interactions with their precise temporal and spatial control.

4.

Announcer: Lóránd Kelemen

Doctoral School: University of Szeged, Doctoral School of Theoretical Medicine, University of Szeged, Doctoral School of Multidisciplinary Medicine

Title of the research topic: Study of cell-cell interactions with optical tweezers

Description of the research topic: The application of optical tweezers in the study of single cells became widespread in the recent decades. This tool enables non-invasive cell manipulation and actuation, as well as the interaction of cells with other cells or micrometer-sized objects. Its extended version, the holographic optical tweezers can provide several trapping focal points therefore it is capable of trapping and actuating complex

microfabricated 3D object with six degrees of freedom. When single cells are attached to these optically actuated micro-objects, these cells can be translated and rotated without the intense trapping beam damaging them. In the research project we plan to study the interaction of two such, indirectly trapped single cells or a trapped cell with a surface-adhered cell layer. The main advantages of the method are the precise temporal control, the possibility of fluorescent observation from multiple viewing directions, the possibility of measuring attachment forces and to realize the cell-cell interactions with freely variable directionality.