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Dancing with magnetism: An attempt to control cell fate

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Mechanical or magneto-mechanical stress applied to the cell membrane, cytoskeleton, or organelles plays a very important role in crucial intracellular processes. In this work, we examine both experimentally and theoretically how a variable either in frequency (0-20 Hz) and/or in amplitude (up to 200 mT) magnetic field dictates magnetic nanoparticles' (MNPs) movements within a cellular environment and how these "dancing" modes affect cell fate. We present here a versatile device and its principle of operation affecting cell growth via mechanical forces exerted on cells during MNPs dancing movements as dictated by the external magnetic field gradients. A prototype 3D printout of a polymer rotating holder (Figure 1) was designed and manufactured. Its operation is based on a DC rotating motor at variable voltage resulting in tunable rotation frequency and in unique magnetic field patterns by different (in size, shape, magnetic force: Fig1c)[i] NdFeB block magnets placed in the slots of a rotating disk (Figs: 1d, 1e). To study, how cells respond to mechanical forces exerted on them during the MNPs "dancing" modes, we applied variable frequency, amplitude and field gradients to HT29 (human colorectal adenocarcinoma) cells incubated initially with commercially available MNPs ferrofluids (Chemicell GmbH[ii]) consisting of an aqueous dispersion of magnetic iron oxides with average hydrodynamic diameters of 100 nm or 200 nm. Such magneto-mechanical effects mediated in HT29 cells generate coordinated cellular responses in both local biochemistry and higher-order biological processes leading to substantial variation on cell proliferation and viability which are strictly related to the applied forces induced by the generated magnetic field gradients as shown in Figure 2.

Figure 1

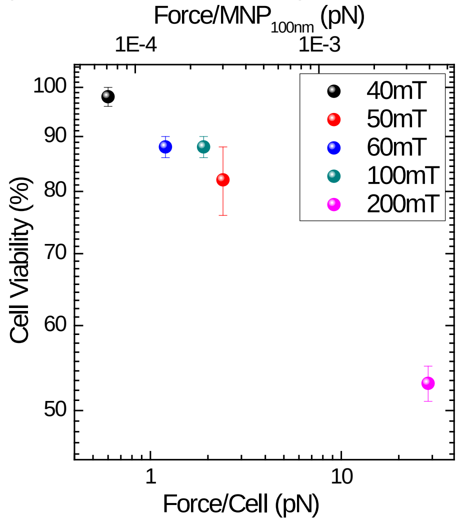

Figure 2

Figure 1: *(a) 3D polymer printout rotating holder for static, alternating or rotating magnetic field penetration of cell samples (b) frequency adjustment of AC field (c) series of block magnets for variable magnetic field configurations (magnetic flux, axial components and gradient fields) (d), (e) Magnetic array setups to create variable magnetic flux modes in sample region. (f), (g) support tables for cell samples.* ***Figure 2:*** *Cell viability dependence on maximum forces extracted from a static external field on 100 nm magnetic nanoparticles (top) and from magnetic nanoparticles on cells (down) with magnetic flux density magnitudes in color scale per force.*

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[i] *http://www.supermagnete.de/eng/block-magnets-neodymium*

[ii] *http://www.chemicell.com/products/magneticfluorescent/index.html*