Università di Brescia

Department of Molecular and Translational Medicine

Piattaforma Imaging

PhD Course in Precision Medicine

Non-invasive microscopy for profiling cellular metabolism and viscoelasticity: Application in macrophage polarisation and biomaterial interfaces

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Abstract: Implanted biomaterials and medical implants can trigger a foreign body response (FBR), a cascade of biological events involving protein adsorption, recruitment of immune cells, formation of foreign body giant cells, and fibrous encapsulation that isolates the implant from the surrounding tissue.

Macrophages are central regulators of this response, coordinating inflammation, tissue repair, and remodelling. Beyond biochemical signalling, macrophages are recognised as mechanosensitive cells, whose intrinsic mechanical properties including cytoskeletal tension, intracellular stiffness, and viscoelasticity change dynamically in response of their physical microenvironment. These biomechanical adaptations actively influence macrophage polarisation, gene expression and consequent functions.

Understanding how macrophage biomechanics are affected by mechanical and topographical cues is crucial for designing immunomodulatory biomaterials. Non-invasive, 3D, and label-free mechanical characterisation techniques, such as Brillouin microscopy, now allow probing these cellular mechanical changes, offering new insights into the interplay between macrophage mechanics and immune function.

In this talk I will present our groups work in FLIM microscopy to profile human macrophage polarisation by proxy of their metabolism, with a machine learning approach to classify their phenotype based on their photonic properties linked to metabolism. I will also discuss our more recent work in Brillouin microscopy to assess the viscoelasticity of polarised macrophages and biomaterial interfaces as a non-invasive approach to monitor cell behaviour.