BIOMECHANICS OF CELLS AND TISSUES: WHAT CAN WE LEARN WHEN WE COMBINE MECHANICAL STIMULI WITH MICROSCOPY?

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Understanding the mechanical properties of biological tissues can shed light on how those tissues work and why, at times, they lose their functionality. Furthermore, a full characterization of a tissue's viscoelastic behavior may provide relevant hints for tissue reparation and tissue engineering. To measure these properties in in-vitro or ex-vivo experiments, researchers often make use of indentation instruments, which looks at how a material deforms under the effect of a calibrated mechanical load. In the first part of my talk, I will show how this technique can be used to determine the mechanical properties of brain slices, and I will comment on which kind of information those measurements can provide. I will show, for instance, that different regions of the brain have remarkably different viscoelastic properties, which seem to be correlated with the cell density measured, in a parallel experiment, via fluorescent microscopy.

As this example highlights, indentation measurements alone are often not sufficient to understand why certain tissues have certain mechanical properties. Under a (not transparent) surface, biological materials are often inhomogeneous and anisotropic. Because the indentation stress propagates several microns deep into the sample, without a proper imaging tool coupled to the indentation instrument, it is impossible to extract useful information on the mechanics of the material the sample is made of. As a point in case, I will show our latest measurements of the mechanical properties of chick embryos, where, combining indentation with optical coherence tomography (OCT), we could precisely map the stiffness of the spine from head to tail – a measurement that may provide interesting cues in the analysis of somites formation and growth. I will also show how the combination of indentation and OCT might find its way in scar and burn classification, introducing a new instrument for skin characterization that our group has just recently completed. Finally, I will show some preliminary results on the use of multiphoton imaging for tissue mechanics characterization. In this last part of the talk, I will show that it is indeed possible to look at the displacement and deformation of cells in a thin slice of tissue while the tissue is compressed by a calibrated mechanical stroke. This approach may pave the way for a much more thorough analysis of the origin of certain mechanical properties of tissues, where the contribution of the individual cells to the viscoelastic features of the materials can be finally disentangle from that of the extracellular matrix.

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