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FROM THE CELLULAR VIA THE TISSUE TO THE ORGAN LEVEL. A JOURNEY EXPLORING BRAIN MECHANICS

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Abstract. I will report on our ongoing journey to decipher the role of brain mechanics at various scales. At the cellular scale, we strive to set up a continuum model for the interaction of cells and extracellular matrix in neuronal network formation. The resulting Partial Differential Equations (PDEs) are of convection-diffusion/advection type and thus challenge their computational implementation. To this end, we develop novel approaches overcoming the computational difficulties inherent to this PDE type. At the tissue scale, we aim at unravelling spinal cord regeneration, a fascinating ability of, for example, Zebra fish but unfortunately absent in humans. As a prerequisite, we endeavor to accurately determine the mechanical properties of spinal cord by different test modalities, that is, indentation and rheometry, and set out to identify and calibrate corresponding continuum models. At the organ scale, we attempt the reconciliation of oftentimes contradictory experimental evidence from ex vivo and in vivo mechanical testing of the brain. We hypothesize that a major contributor to these discrepancies is the vascularization and corresponding blood pressure pulsation. In order to better understand magnetic resonance elastography of the brain we establish a protocol for virtual Magneto-Rheological Elastomer (MRE) testing. The key challenge is thereby the inversion of the wave equation for elastic and viscoelastic soft materials.

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