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Inverse and recursive approaches to discover and predict emergent behaviour in complex biosystems comprising human tissues

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Through combination of novel microscopy protocols for imaging live cells and tissues as well as experimental mechanics methods, we have begun to elucidate mechanisms underpinning emergent properties of hierarchical materials such as tissues [1,2]. We refer to the process as Microscopy Aided Design And Manufacture (MADAMe). We apply this paired imaging and computational technology approach to engineer advanced materials that emulate the smart mechanical properties of tissues. These materials have applications in diverse arenas, from medical implants to the transport and sports industries. Our "bottom up" approach to emulating mechanically responsive natural materials integrates the fields of multiscale biomechanics and mechanobiology in novel ways and underscores the role of mechanics in life. It also elucidates how "brainless" cells adapt to dynamic mechanical environments by constantly weaving and thereby adapting their own niche [3]. In addition, our connectomics approach to understanding cell networks *in situ*, in tissues as diverse as brain and bone, provides a basis for a new approach to diagnostics, predicting emergent disease states using an epidemiological approach in cell populations within individual patients [3,5,6]. Challenges to the connectomics approach include acquisition, handling and archiving of massive data sets, discrepancies in technical capacities (e.g. resolution) of imaging methods, and hard and software approaches, as well as bridging and upskilling of research teams to apply a transdisciplinary approach using innovative conceptual, experimental, and translational approaches. This talk integrates our understanding of cells, expert tissue prototypers, and their networks, to emulating cellular approaches to engineer and manufacture materials and medical devices of the future.

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[5] Eberle A-L *et al. J Microscopy* (2015) 259, 114.
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