Protein phase separation and emergent material properties

Phase separation has emerged as a new paradigm currently revolutionizing our understanding of cell biology and intracellular organization. The assembly of biomolecules into condensed liquid phases (i.e condensates) appears to underlie the formation of membraneless organelles and other liquid compartments with roles in cell signaling, transcriptional regulation and cytoskeletal organization. Understanding the role of liquid material properties in condensate function and dysfunction requires new tools and approaches. We employ model in vitro systems and a combination of quantitative imaging and rheological tools to interrogate the nature of liquid material properties and their contribution to molecular processes and functions. We find that protein-protein and protein-RNA interactions can tune the material properties of condensates; Conversely, the viscous network of condensates can in turn modulate the molecular diffusion within droplets in a length scale dependent manner. This work provides important insight into the physicochemical rules that govern the regulation of protein/RNA liquid phases, from the cellular functions of membraneless organelles, to the potential misregulation of liquid phase separation in disease.

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