The Physics of Soft and Biological Matter

(invited) Scaling laws of polymer membranes: from synthetics to nuclear envelopes and mechanotransduction

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Self-assembled membranes abound in biology, but lipids are not the entire story – protein polymer assemblies often add key physical properties to biological membranes. We have explored this with synthetic polymer membranes, called polymersomes, and also with the nuclear membrane or lamina that surrounds and protects the DNA in most eukaryotic cell types. Block copolymer amphiphiles of various molecular weights can generate vesicles, and we will review the broad variations of properties, including mechanical properties, as well as the segregation of mixed systems [1]. Our efforts with the nuclear lamina began with proteomics analyses of adult tissues [2] that reveal the nucleoskeletal protein lamin-A follows polymer physics scaling as a function of tissue elasticity, *E*, as do numerous collagens that directly determine *E*. Lamin-A confers a viscous stiffness to nuclei from high stress tissues where it predominates, whereas lamin-B's scale weakly with *E* and confer elasticity to nuclei. Differentiation of stem cells to fat or bone is respectively enhanced by low or high lamin-A levels, and nuclear entry of transcription factors prove to be lamin-A-regulated. Complementary insights are obtained for marrow cells for which nuclear deformability also regulates cell trafficking [3]. Tissue stiffness and stress thereby couple to lineage and lamins.

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[2] J. Swift, I.L. Ivanovska, A. Buxboim, T. Harada, P.C. D.P. Dingal, J. Pinter, J.D. Pajerowski, K. Spinler, J-W. Shin, M. Tewari, F. Rehfeldt, D.W. Speicher, and D.E. Discher. Nuclear Lamin-A Scales with Tissue Stiffness and Enhances Matrix-directed Differentiation. *Science* 341: 1240104-1 to 15 (2013)

[3] J-W. Shin, K.R. Spinler, J. Swift, J. Chasis, N. Mohandas, D.E. Discher. Lamins regulate cell trafficking and lineage maturation of adult human hematopoietic cells. *Proceedings of the National Academy of Sciences – USA* (2013)