TWO DISTINCT REGIMES OF CYTOSKELETAL DYNAMICS

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The dynamics of the cytoskeleton (CSK) determines how a living cell interacts with its mechanical environment and influences a wide range of cell functions. Physical laws governing CSK dynamics are poorly understood, however, and there is no consensus as to underlying mechanism. On the one hand, CSK dynamics in the adherent cell in culture exhibits a striking analogy to that of inert soft glassy materials such as foams, colloids, slurries, and some weak gels, and observed non-equilibrium behaviours include anomalous transport, molecular trapping, intermittency, and approach to kinetic arrest [1,2]. On the other hand, dynamics of reconstituted F-actin gels in vitro show clear evidence that fluctuations in semiflexible polymers are driven by thermal forces [3,4], but such equilibrium dynamics have yet to be observed in the living cell. We show here for the first time in living cells (airway smooth muscle) that these two regimes coexist but on distinct time scales. On shorter time scales (higher frequencies), there is insufficient time for structural rearrangements and, as such, relatively fast thermal fluctuations drive bending of semiflexible CSK filaments and determine material properties. On longer time scales (lower frequencies), however, slow glassy rearrangements of the CSK prevail and the effects of thermally driven filament bending become subdominant. The transition between regimes occurs on timescales of the order 10^{-2} s. Given sufficient time, semiflexible polymer dynamics become subdominant and slow non-equilibrium modes prevail, thus placing within the glassy regime timescales typical of integrated mechanical events such as cell spreading, pattern formation, crawling, contraction, and wound healing.

References

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Key words: Cytoskeleton, networks, magnetic twisting cytometry, airway smooth muscle