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Coupling of Active Motion and Advection Shapes Intracellular Cargo Transport PHILIPP KHUC TRONG, Department of Physics, and Department of Applied Mathematics and Theoretical Physics, University of Cambridge, JOCHEN GUCK, Department of Physics, University of Cambridge, RAYMOND GOLDSTEIN, Department of Applied Mathematics and Theoretical Physics, University of Cambridge — Three different mechanisms can contribute to intracellular cargo transport: (1) passive diffusion, (2) active motor-driven transport along cytoskeletal filament networks and (3) passive advection by fluid flows. Active and advective transport are coupled because cytoplasmic flows can arise through entrainment of the fluid that surrounds actively moving cargo on cytoskeletal networks. Here, we report a reaction-advection-diffusion model for transport of a passive mass-conserved scalar that can cycle between a bound state, where advection represents active transport on a cytoskeletal network, and an unbound state, where the advecting fluid flow field is driven by forces from the cytoskeletal network. Cargo transport and localization patterns are explored for different cytoskeletal network topologies and for varying reaction kinetics. We find that for sufficiently low diffusion, localization of cargo to a target area is optimized either by low reaction kinetics and decoupling of bound and unbound state, or by a mostly disordered cytoskeletal network with only weak directional bias. The principles exemplified by this model likely have implications for our understanding and interpretation of transport patterns and cytoskeletal network structures.

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