Abstract Submitted
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Active carpets, part 2: Generalisation of Fick's laws for enhanced diffusion and particle capture by life at interfaces[1] ARNOLD JTM MATHIJSSEN[2], Stanford University, FRANCISCA GUZMAN-LASTRA, Universidad Mayor, Santiago, Chile, MANU PRAKASH, Stanford University, HARTMUT LOEWEN, Heinrich Heine University Duesseldorf — Fluctuations lie at the core of biological processes, facilitating diffusive transport and driving the cell's molecular machinery. Fick's laws of diffusion are well established in classical thermodynamics, but living systems operate far from thermal equilibrium as energy is injected locally by activity, which can give rise to surprising effects not captured by passive diffusion. Especially on surfaces this metabolic activity is highly concentrated, from molecular motors through ciliary arrays to sessile suspension feeders and bacterial biofilms, together forming the class of 'active carpets'. Here, we consider the flows generated by these different active surfaces and show how they can enhance diffusion, directed transport, and particle capture. We derive the diffusion coefficients as a function of distance from these active carpets and we formulate the corresponding generalised Fick's laws. These laws feature remarkable solutions, including non-Boltzmannian sedimentation profiles with particles hovering a finite distance above the active carpet, and enhanced particle capture by a raised diffusive flux. Our results shed new light on the non-equilibrium properties of materials with active boundary conditions and life at interfaces.

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