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Optimal Concentrations in Transport Networks KAARE JENSEN, JESSICA SAVAGE, Harvard University, WONJUNG KIM, JOHN BUSH, Massachusetts Institute of Technology, N. MICHELE HOLBROOK, Harvard University — Biological and man-made systems rely on effective transport networks for distribution of material and energy. Mass flow in these networks is determined by the flow rate and the concentration of material. While the most concentrated solution offers the greatest potential for mass flow, impedance grows with concentration and thus makes it the most difficult to transport. The concentration at which mass flow is optimal depends on specific physical and physiological properties of the system. We derive a simple model which is able to predict optimal concentrations observed in blood flows, sugar transport in plants, and nectar feeding animals. Our model predicts that the viscosity at the optimal concentration $\mu_{\text{opt}} = 2^n \mu_0$ is an integer power of two times the viscosity of the pure carrier medium μ_0. We show how the observed powers $1 \leq n \leq 6$ agree well with theory and discuss how n depends on biological constraints imposed on the transport process. The model provides a universal framework for studying flows impeded by concentration and provides hints of how to optimize engineered flow systems, such as congestion in traffic flows.

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