Biophysics and Systems Biology Seminar Series

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Designing a maze to help random walkers find their way: Diffusive search within reticulated organelles

Abstract: Proteins inside cells must find distributed targets, such as binding sites or reaction partners, and these searches usually involve a diffusive component. Although the impact of search strategy on how quickly a randomly walking searcher finds its target, there is comparatively little guidance on how to construct the search domain to decrease search time. Eukaryotic cells are largely divided into distinct compartments with a variety of morphologies, including the reticulated (i.e. composed of a network of tubes) endoplasmic reticulum (ER) and mitochondria. By considering search within these tubular organelles as diffusion along a spatial network of nodes and edges, I ask which network characteristics (and thus mitochondrial and ER network shapes) decrease diffusive search time. This question is explored on synthetic networks whose characteristics can be controlled, and networks derived from imaging the mitochondria and ER networks of living cells. Using stochastic simulations and exact calculations, I show that simple geometric characteristics largely control the typical diffusive search time on a network. More rapid search on wild-type mitochondrial networks, relative to mutant networks, is also explained by the geometric characteristics of wild-type and mutant mitochondrial networks. Additionally, search times on ER and mitochondrial networks are similar to those on synthetic networks, suggesting the lessons from simpler synthetic networks extend to more complex biological systems.

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Hosts: Rob Taylor and Professor Jun Allard
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