Intracellular transport of insulin granules is a subordinated random walk

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We quantitatively analyzed particle tracking data on insulin granules expressing fluorescent fusion proteins in MIN6 cells to better understand the motions contributing to intracellular transport and, more generally, the means for characterizing systems far from equilibrium. We find anomalous diffusion. Interpreting such data conventionally requires assuming that a process is either ergodic with particles working against fluctuating obstacles (fractional Brownian motion (FBM)) or nonergodic with a broad distribution of dwell times for traps (continuous-time random walk (CTRW)). However, we find that statistical tests based on these two models give conflicting results. We resolve this issue by introducing a subordinated scheme in which particles in cages with random dwell times undergo correlated motions owing to interactions with a fluctuating environment. We show that a simple hybrid model that combines FBM and CTRW through subordination accounts for all of the observations. Analysis of the granule motion in the presence of vinblastine, a microtubule-disrupting drug, allows us to relate the dynamics to the structure of the microtubule network. We also present simulations showing that our kinetic scheme can account for the otherwise unexplained apparent granule storage pools and biphasic secretion of insulin.

References

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