Excitonic transport via aromatic amino acid chromophore networks in tubulin polymers

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Abstract

Similar to the uniquely arranged chromophores in light-harvesting complexes that drive photosynthesis, tubulin subunit proteins possess a distinct architecture of aromatic amino acids (tryptophan, tyrosine, etc.) which can serve as chromophores in the inverse process: aerobic respiration. The geometry and dipolar properties of these aromatics are similar to those found in photosynthetic units, indicating that tubulin may support coherent energy transfer. Tubulin aggregated into polymeric lattices called microtubules may support such energy transfer, which could be important for biological signaling and communication essential to living processes, particularly in the brain. Microtubules reorient and reorganize in a dose-dependent manner after exposure to UV light, with the greatest effect being observed around 280 nm, and functional microtubule networks may use the energy from this UV light as a signaling mechanism throughout the cytoskeleton. Neuroinflammation, a hallmark of Alzheimer's disease and other dementias, arises in part from the overproduction of free radicals and this cascade of UV emissions. We have studied energy transfer between chromophoric amino acids in tubulin polymers via transition singlet dipole-dipole interactions coupled to the surrounding thermal environment (Haken-Strobl model). Through repeated simulation of coherent "hopping" events, similar to environment-assisted quantum transport, we calculate the probability distribution of site localization given an initial photoexcitation at a particular aromatic amino acid along the polymer. Our results provide a plausible basis favoring a quantum mechanism of signal propagation and suggest that this coherent energy transfer is at least relevant on dendritic length scales. These studies could address a critical barrier to progress in the field of neurodegeneration by developing a mechanistic explanation of how light produced from aerobic respiration may affect cytoskeletal signaling, genomic regulation, and other coherent cellular processes.

Seminario

Lunedì 10 luglio 2017
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