Room-Temperature Biological Quantum Random Walk in Phycocyanin Nanowires

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The importance of quantum processes in biology is starting to be recognized. Quantum processes are being discussed in the context of enzyme function, olfaction, magnetic sensing and most prominently in photosynthetic light-harvesting complexes. These findings suggest that a key to the survival of quantum coherence at ambient temperatures is the interplay between long-lived vibrational modes and the electronic degrees of freedom that can lead to coherent effects. This coherence can explain the high yield of photosynthetic exciton transfer. Furthermore, it is fair to say that no device made by man so far has made use of all these properties at the same time.

We aim to understand and control these phenomena in order to build up a large scale long range composite quantum system with global non-classical properties. Utilizing light harvesting complexes we were able to fabricate self-assembled nano-energy guides. We used isolated Phycocyanin (PC) proteins that can self-assemble into bundles of nanowires. We show two methods for controlling the organization of the bundles. These nanowires exhibit long range quantum energy transfer through hundreds of proteins. Such results may provide new efficient building blocks for coupling to nano-devices. However, many open questions regarding the distribution and the efficiency of energy transfer mechanisms in biological systems and its quantum nature remain open.