

Coherence in photosynthesis: Experimental signatures of long lived oscillations have been observed with two dimensional electronic spectroscopy. Debate continues over whether these signals arise from electronic or vibronic coherence, but non monotonic noise assisted transfer remains a testable prediction.

Radical pair magnetoreception: Models predict singlet triplet interconversion rates sensitive to geomagnetic fields of  $\sim 50$  uT. Weak radiofrequency fields at MHz frequencies can disrupt orientation, serving as behavioral probes. Cryptochrome proteins remain prime candidates.

Enzyme catalysis and tunneling: Kinetic isotope effects often exceed semiclassical limits, consistent with hydrogen tunneling. Temperature independent isotope ratios and deviations from Arrhenius behavior provide experimental markers.

Olfaction: The vibrational theory suggests inelastic electron tunneling contributes to odor discrimination. Evidence remains mixed; rigorous double blind receptor level assays with deuterated odorants are required to test this.

Genetic stability: Proton tunneling in DNA base pairs may generate transient tautomeric forms. Ultrafast spectroscopy has detected femtosecond tautomer lifetimes, which could lead to replication errors under certain conditions.

Quantum thermodynamics: Recent fluctuation theorem experiments in nanoscale systems show entropy production can be sensitive to coherence. NV center thermometry allows probing such effects in living cells.

Leggett Garg tests: Temporal correlation inequalities provide operational criteria to detect non classical dynamics. Application to single enzyme trajectories could identify deviations from classical renewal processes.

Consciousness and quantum processes: Macroscopic quantum states in the brain remain speculative. More tractable are spin chemical pathways in proteins, which can be probed with controlled magnetic perturbations. Even null results provide valuable constraints.