

Technical Endnotes Enzyme Tunneling Evidence Large, temperature-independent kinetic isotope effects (KIEs) in hydrogen-transfer reactions exceed classical limits. See: Klinman, J.P. (2006). "Linking protein dynamics to catalysis: hydrogen tunneling at enzyme active sites." *Phil. Trans. R. Soc. B. Promoting Vibrations Hypothesis* Low-frequency protein motions dynamically compress donor-acceptor distances, enhancing tunneling probability (Warshel, A., Hammes-Schiffer, S.). Photosynthetic Coherence 2D electronic spectroscopy on the FMO complex (Engel et al., *Nature* 2007) revealed oscillations interpreted as electronic coherence; debates remain regarding vibrational vs electronic origins. Environment-Assisted Quantum Transport (ENAQT) Proposed model where environmental noise prevents excitons from trapping while short-lived coherence enables efficient exploration (Rebentrost et al., *New J. Phys.* 2009). Magnetoreception Radical pair mechanism in avian cryptochromes: entangled electron spins interconvert between singlet/triplet states influenced by Earth's magnetic field (Ritz et al., *Nature* 2000). DNA Tautomerization Proton tunneling may underlie spontaneous point mutations (Lowdin, P.O., 1963; recent quantum chemical simulations confirm plausibility). AI-Assisted Spectral Analysis Machine learning approaches are increasingly applied to multidimensional spectroscopy, helping distinguish quantum-consistent signatures from classical noise (Royo et al., *J. Chem. Phys.* 2020).