# Quantum Biology of Magnetoreception

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Despite an established consensus that many forms of life can reliably detect the Earth's weak magnetic field, it is unclear how many complex organisms sense it [1]. Most prominent mechanistic proposals invoke a quantum-biological model [2], relying on the assumption that an excitonic “radical” electron pair [3] facilitates magnetoreception of the Earth's field (50 µT).

Field-dependent decay products of this spin-crossing reaction are believed to constitute a decoherence channel to a signaling state that discriminates the field angle and inclination, yet essential details of the scheme are lacking. Comprehensive models of requisite activation [4-6], charge separation [7-8], chemical amplification [9-10], anisotropic response [11], coherence-preserving [12] and/or decoherence-limiting [13] steps are needed. Given the rich complexity of the biological *milieu* and lacking a consistent *in vitro* model, mechanistic features must be identified empirically in order to confirm a viable magnetic sense receptor.

In this seminar lecture, I review features of competing models of cryptochrome-based magnetoreception, in the context of existing theory and experiment. Seminar content will address recent conflicts [14-17] between evidences and conventional model proposals [18-19]. Implications of these conflicts will be explored in terms of an expanded model that involves the amplification of the spin-chemical effect—with an eye toward broad generalization of existing principles [20-23]. We assess criticism of models reliant on quantum entanglement in a dynamic environment at physiological temperature [24-28]. If time permits, we will discuss overall challenges facing a broad class of reaction schemes that depend upon coherent singlet-triplet interconversion to enable magnetoreception. In closing, we will consider how the engineering of biosynthetic systems [29] could enable new technologies with ramifications for metrology [30], magnetogenetics [31], and medicine [32].

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