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Magnetic compasses in biological systems: Does quantum physics play a role?

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One hypothesis of the process underlying the magnetic compass of animals surmises that the magnetic field is perceived by its effect on the coherent spin evolution within a non-equilibrium photochemical radical pair reaction. If this hypothesis were proven, it would be a dramatic demonstration of a quantum process with clear biological significance. We will review the physics of the radical pair mechanism and the current state of evidence supporting it. Experimentally, we will focus on the use radio-frequency magnetic fields to affect a radical-pair based mechanism in birds and discuss the approach and its limitations. Theoretically, we will focus on the question of how one should design a radical pair to be optimally sensitive to the direction of a weak magnetic field. Regardless of whether or not a radical pair mechanism is indeed used by birds or other animals, optimal design features could be used to manufacture biologically inspired, but man-made magnetic compass systems.