# The chemistry underlying robins' magnetic sense


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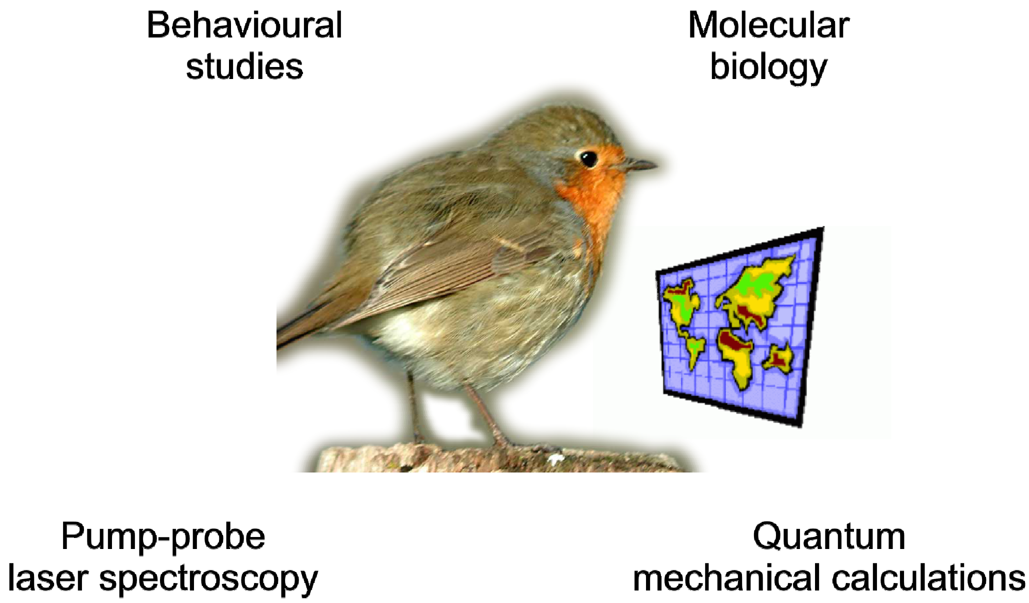


Many species of bird and other animals are able to sense the Earth's magnetic field. The Robin redbreast (*Erithacus rubecula*) was shown to use such a sense for navigation in the 1960's[1]. Since then many behavioural studies have confirmed this result and uncovered details of the birds' magnetic perception. Yet, to this day, the biochemistry and neurophysiology underlying the magnetic sense are unknown. In this talk, I explain the contribution of physical chemistry experiments and calculations carried out in Oxford towards resolving this fascinating puzzle.

To begin, I outline some important clues to the underlying mechanism provided by behavioural studies. For example: robins are sensitive only to the inclination of a magnetic field, not its polarity; robins orient under blue/green ambient light, but not with red/yellow light; and robins orient only in a narrow range of field strengths. These observations are consistent with a receptor located in the eye, which detects the Earth's magnetic field via changes in the yield of a photochemical reaction involving spin-correlated radical pair intermediates[2].

Chemical reactions whose rate and/or product yield vary with applied magnetic field are well known[3]. Quantitative experiments conducted in Oxford and elsewhere have allowed the development of a reliable theory for such reactions. This theory and appropriate experiments offer a complementary approach to testing the "radical pair" hypothesis in birds.

I discuss studies of a photochemical reaction between two small molecules, pyrene and 1,3-dicyanobenzene. Under UV irradiation in a viscous solvent, these species react to form a fluorescent exciplex. The extent of exciplex formation depends on the applied magnetic field. Crucially, it also depends on the frequency and orientation of an additional radio-frequency magnetic field. It has been proposed that using radio-frequency fields in behavioural studies might form a powerful test of the radical pair hypothesis[4,5]. Preliminary results support a role for radical pairs in the avian magnetic sense.

Finally, I discuss experiments on a specially-designed carotenoid-porphyrin-fullerene triad molecule. This molecule may undergo intramolecular electron transfer to form a pair of long-lived radicals[6]. I show that reaction yields in this species may be altered by Earth-strength magnetic fields. Furthermore, in frozen samples these yields depend on the orientation of the magnetic field. This chemical model shows proof of concept for Earth-strength field and orientation sensitivity, lending support to the radical pair hypothesis.

These physico-chemical studies make an important contribution to the interdisciplinary debate on the fascinating magnetic sense of birds.

## Acknowledgements:

I am grateful for support and supervision from Peter Hore and Christiane Timmel. I thank our collaborators Devens Gust, Thorsten Ritz, Henrik Mouritsen, Roswitha Wiltschko and Wolfgang Wiltschko for helpful discussions.

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