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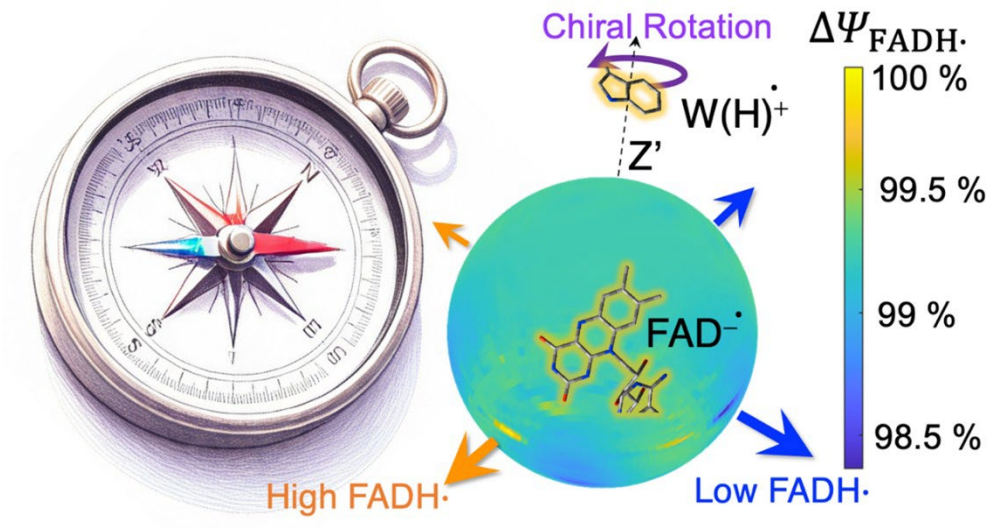
PRESS RELEASE | October 30, 2026

Small Molecular Twists May Strengthen Nature's Magnetic Compass

Chirality-induced spin selectivity may enhance magnetic-field direction sensing in cryptochrome

KOBE, JAPAN — A collaborative research team led by KOBORI Yasuhiro at Kobe University, together with researchers from Toho University, Saitama University, Nagoya Institute of Technology and the University of Freiburg, has identified a potential molecular mechanism that could enhance magnetic compass responses in cryptochrome, a blue-light-sensitive protein implicated in magnetoreception.

Using time-resolved electron paramagnetic resonance (EPR) spectroscopy, the team identified structural rearrangements in light-induced intermediates and a contribution from chirality-induced spin selectivity (CISS). Their analysis suggests that chiral rotational motion of a tryptophan residue can influence electron-spin polarization and enhance the directional dependence of downstream chemical reactions.



Overview | Proposed cryptochrome magnetic-compass mechanism involving chirality-induced spin selectivity. © Yasuhiro Kobori, The Journal of Physical Chemistry Letters (2026), CC BY.

How might living organisms sense Earth's magnetic field?

Migratory birds and other organisms are thought to use Earth's magnetic field for directional information. Cryptochrome contains flavin adenine dinucleotide (FAD), which absorbs blue light and initiates sequential electron transfer from tryptophan residues. The resulting charge-separated radical pairs have two unpaired electron spins whose singlet–triplet dynamics can depend on the external magnetic field.

CISS links molecular chirality to preferential spin transport. Whether motion within cryptochrome can produce this effect and influence a radical-pair compass has remained largely unexplored.

Tracking molecular motion and electron-spin dynamics

The researchers examined Xenopus laevis cryptochrome-DASH using time-resolved EPR following pulsed laser excitation, at temperatures from −153 °C to −33 °C. Quantum-mechanical simulations incorporated CISS, exchange coupling, electron–electron dipolar coupling and hyperfine interactions.

The spectra supported a structural rearrangement involving chiral rotation of the oxidized tryptophan $W_B(H)^{\bullet+}$ in the second charge-separated state, $FAD^{\bullet-}\cdots W_B(H)^{\bullet+}$, with an estimated CISS contribution of 8%. A smaller contribution, no greater than 6%, was inferred for the longer-range $FAD^{\bullet-}\cdots W_C(H)^{\bullet+}$ state. The findings support transfer of spin coherence generated during the earlier charge-separation step to the terminal radical pair.

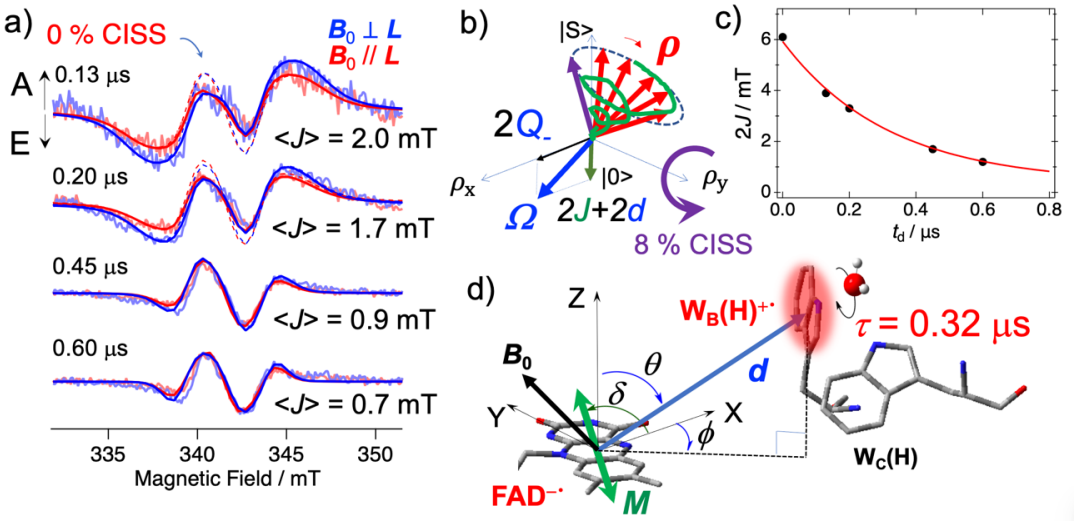


Figure 1 | Time-resolved EPR and quantum-model analysis of the charge-separated state, including the proposed chiral rotation of tryptophan $W_B(H)^{\bullet+}$. © Yasuhiro Kobori, The Journal of Physical Chemistry Letters (2026), CC BY.

Small spin selectivity, stronger directional response

Calculations of the signaling-state reaction yield predicted a normalized anisotropy of approximately 0.3% without CISS. Including a 6% CISS contribution increased the predicted anisotropy to 1.6%. The model also predicted differences between responses to reversed magnetic-field directions, reflecting the coupling of chiral spin polarization to radical-pair dynamics.

The enhanced directional response is a theoretical prediction based on spectroscopic analysis, not a direct demonstration of magnetic navigation in living animals.

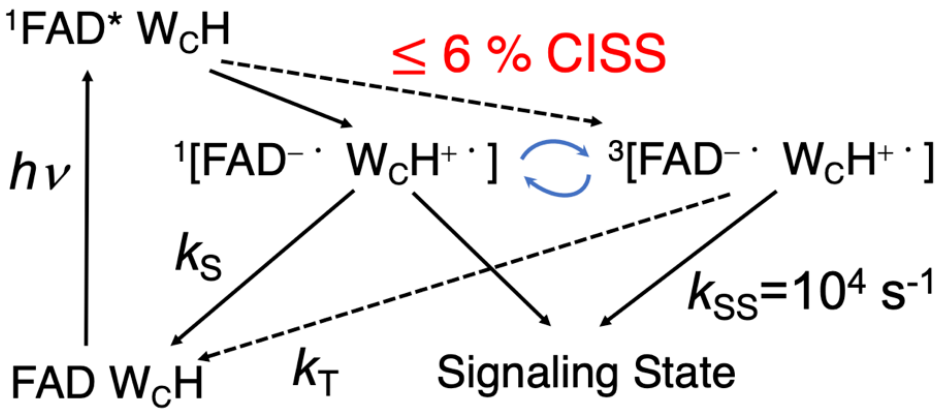


Figure 2 | Proposed spin conversion and chemical reaction pathways linking singlet and triplet radical pairs to signaling products. © Yasuhiro Kobori, The Journal of Physical Chemistry Letters (2026), CC BY.

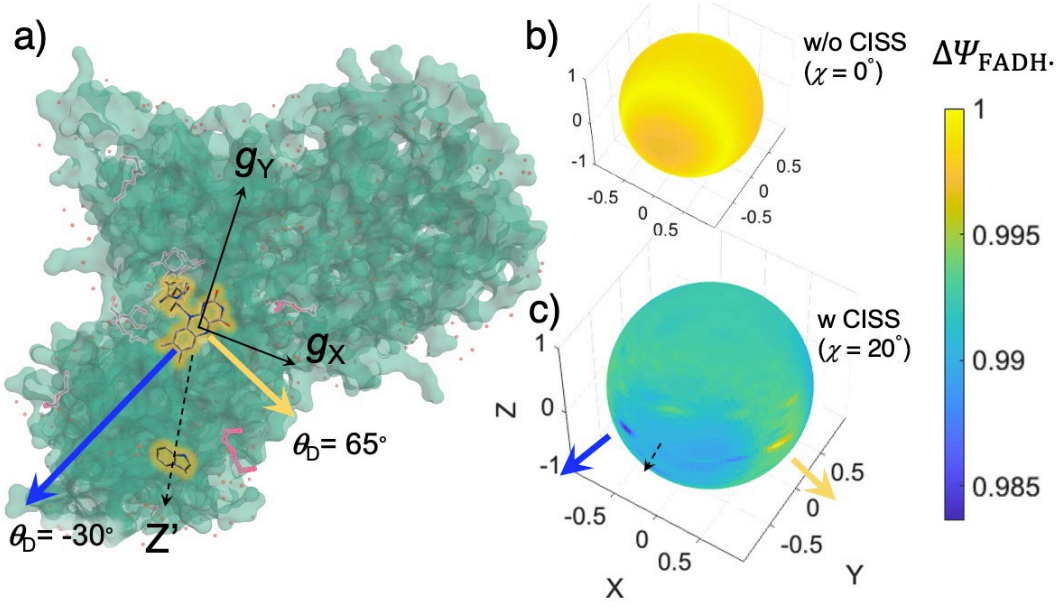


Figure 3 | Predicted spatial anisotropy of signaling-product yield without and with CISS; the model predicts enhancement from 0.3% to 1.6% at 332.5 mT. © Yasuhiro Kobori, The Journal of Physical Chemistry Letters (2026), CC BY.

Implications and next steps

The results connect local conformational motion to quantum spin dynamics and suggest a route by which subtle protein motion could strengthen magnetic-field sensitivity. Future studies will test the predicted reversal of spin-polarization signals and measure how molecular dynamics affect signaling yields. The findings may inform biomolecular magnetic sensors and research on biological magnetoreception.

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Acknowledgments

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