A molecular compass for bird navigation

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Like the collective motions of bird flocks, the patterns result from the concerted interactions of many individual particles without a central coordinator. Credit: Wikipedia.

Each year, the Arctic Tern travels over 40,000 miles, migrating nearly from pole to pole and back again. Other birds make similar (though shorter) journeys in search of warmer climes. How do these birds manage to traverse such great distances when we need a map just to make our way to the next town over?

Researchers have established that birds can sense the earth's magnetic field and use it to orient themselves. How this internal compass works, though, remains poorly understood.

Physicists at the University of Oxford are exploring one possible explanation: a magnetically sensitive protein called cryptochrome that mediates circadian rhythms in plants and animals. Blue or green light triggers electrons in the protein to produce pairs of radicals whose electron spins respond to magnetic fields. "As we vary the strength of the magnetic field, we can alter the progress of these photochemical reactions inside the protein," said lead researcher Peter Hore, who will present his work during a talk at the American Physical Society's March Meeting on Wednesday, March 4 in San Antonio, Texas.

Behavioral experiments have shown that even subtle disruptions to the magnetic field can impact birds' ability to navigate. In a study led by Henrik Mouritsen, in collaboration with Hore, robins were placed in wooden huts on campus at the University of Oldenburg in Germany. Without supplementary visual cues like the sun's position in the sky, the birds struggled to navigate. They only regained their ability to orient themselves when the huts were covered in aluminum sheeting and electrically grounded, blocking external oscillating electromagnetic noise but not the earth's static magnetic field.

The researchers concluded that even low-level electromagnetic noise in the frequency range blocked by the aluminum screens—probably coming from AM radio signals and electronic equipment running in buildings —somehow interfered with the urban robins' magnetic orientation ability.

Hore hopes that the behavioral findings in the field can inform his molecular-level work in the laboratory.
"We would like to know how such extraordinarily weak radiofrequency fields could disrupt the function of an entire sensory system in a higher vertebrate. Our feeling is that this is likely to provide key insights into the mechanism either of the magnetic compass sense or of some important process that interferes with the birds' orientation behavior," said Hore.

One explanation is that the electromagnetic noise has quantum-level effects on cryptochrome's performance. This would suggest that the radical pairs in cryptochrome preserve their quantum coherence for much longer than previously believed possible. Such a finding could have broader implications for physicists hoping to extend coherence for more efficient quantum computing.

"Physicists are excited by the idea that quantum coherence could not just occur in a living cell, but could also have been optimized by evolution. There's a possibility that lessons could be learned about how to preserve coherence for long periods of time," said Hore.

More information: meeting.aps.org/Meeting/MAR15/Session/M46.4

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