

# Reverse-Engineering the Quantum Compass of Birds

By Brandon  
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Scientists are coming ever closer to understanding the cellular navigation tools that guide birds in their unerring, globe-spanning migrations.

The latest piece of the puzzle is superoxide, an oxygen molecule that may combine with light-sensitive proteins to form an in-eye compass, allowing birds to see Earth's magnetic field.

"It connects from the subatomic world to a whole bird flying," said Michael Edidin, an editor of *Biophysical Journal*, which published the study last week. "That's exciting!"

The [superoxide](#) theory is proposed by Biophysicist Klaus Schulten of the University of Illinois at Urbana-Champaign, lead author of [the study](#) and a pioneer in avian magnetoreception. Schulten first [hypothesized in 1978](#) that some sort of biochemical reaction took place in birds' eyes, most likely producing electrons whose spin was affected by subtle magnetic gradients.

In 2000, Schulten [refined this model](#), suggesting that the compass contained a photoreceptor protein called [cryptochrome](#), which reacted with an as-yet-unidentified molecule to produce pairs of electrons that existed in a state of [quantum entanglement](#) — spatially separated, but each still able to affect the other.

According to this model, when a photon hits the compass, entangled electrons are scattered to different parts of the molecule. Variations in Earth's magnetic field cause them to spin in different ways, each of which leaves the compass in a slightly different chemical state. The state alters the flow of cellular signals through a bird's visual pathways, ultimately resulting in a perception of magnetism.

Far-fetched as it sounds, subsequent research from multiple groups has found [cellular evidence of such a system](#). Molecular experiments suggest that it's indeed [sensitive to Earth's geomagnetics](#), and computational models suggest a level of quantum entanglement [only dreamed of by physicists](#), who hope to use entangled electrons to store

information in quantum computers.

But though cryptochrome is likely part of the compass, the other part is still unknown. In April, another group of magnetoreception researchers showed that oxygen could interact with cryptochrome to produce [the necessary electron entanglements](#). Schulten's latest proposed role for superoxide, an oxygen anion found in bird eyes, fits with their findings.

Eddin cautioned that "this is still not an experimental demonstration. It's a possibility."

As for the perceptual result of the compass, it remains a mystery. Some researchers think birds might see a dot at the edge of their vision, swiveling according to the direction they're facing. Others think it might produce effects of color or hue. Perhaps migrating birds fly towards the light.

#### **See Also:**

- [Hacking Salmon's Mental Compass to Save Endangered Fish](#)
- [Google Earth Reveals Sixth Sense of Cattle, Deer](#)
- [Cows Really Do Have a Magnetic Sixth Sense](#)

*Citations: "Magnetoreception through Cryptochrome May Involve Superoxide." By Iliia A. Solov'yov and Klaus Schulten. Biophysical Journal, Vol. 96 Issue 12, June 17, 2009.*

*"Quantum coherence and entanglement in the avian compass." By Elisabeth Rieper, Erik Gauger, John J. L. Morton, Simon C. Benjamin, Vlatko Vedral. arXiv, June 19, 2009.*

*"Magnetic Compass of Birds Is Based on a Molecule with Optimal Directional Sensitivity." Thorsten Ritz, Roswitha Wiltschko, P.J. Hore, Christopher T. Rodgers, Katrin Stapput, Peter Thalau, Christiane R. Timmel and Wolfgang Wiltschko. Biophysical Journal, Vol. 96 Issue 8, April 22, 2009.*

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Brandon Keim's [Twitter](#) stream and [reportorial outtakes](#); [Wired Science on Twitter](#).

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