Klaus Schulten on how birds navigate

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Today, Adam Bergner, of Linkoping, Sweden, asks “how are birds able to navigate?”

There are many theories, and a recent one came from Klaus Schulten, a biophysicist at the University of Illinois at Urbana-Champaign. He said birds usually navigate by physical landmarks, like highways or coastlines. But, in extreme weather or as they fly over oceans, they use a sort of internal compass.

Klaus Schulten: Many of us think that there are two compass senses in birds and other animals: one, that likely relies on magnetite. The other one is a biochemical reaction that is connected with visual system.

Magnetite – a mineral with magnetic properties – is found in some birds’ beaks. Schulten believes it helps birds identify strong or weak magnetic fields on Earth’s surface. He thinks birds also utilize Earth’s pervasive, global magnetic field – the one that guides our compasses.

Klaus Schulten: And that is more the general map that they need to use when they are in completely unknown territory.

Schulten believes that ability comes from a light-sensing protein, located in only one eye of the bird. The protein picks up signals, based on light, to send messages to the brain about the direction of the magnetic field.

Klaus Schulten: The problem – but also partially the answer – of how birds navigate is that one cannot see an obvious compass. But rather, one has to get cues from the behavior responses of the bird. One important clue is that apparently light influences how birds navigate.

Schulten said scientists learned that light influences birds by studying birds in cages. During the start of their migrating season, the birds would group in the corner of the cage they want to fly from. When the scientists changed the ambient light in the room to a light that doesn’t contain the blue part of the spectrum, the birds sit in all four corners of the cage.

Klaus Schulten: Some birds, very conveniently, have this ability that is apparently connected to their eyesight only in one eye. If you kept the wrong eye of the bird, they still orient. But if you take the right eye, the birds again miss the orientation sense. And then you realize the sense must be in the eye of the bird, and in one of the eyes of the bird. That’s how you realize where this compass is located.

Many scientists believe this compass is associated with what’s called a free-radical pair mechanis which involves molecules detecting the magnetic pull of the North and South poles. The free-radical pair may be connected to cryptochrome, the light-sensing protein in the bird’s eye.

Klaus Schulten: This compass cannot differentiate between north and south. It can only show the lines that go from south to north on the magnetic earth. It cannot only show the direction of the magnetic field north, or east, or west or south, but it can also show direction into the ground. Turns out the magnetic field lines around the Earth’s surface are not parallel to the surface, as you may think, but rather they go from the northern hemisphere into the surface. And so

the bird sees actually, a magnetic line that goes on one side into the earth, and on the other into the sky.

Schulten says that he would like to know much more about how birds navigate.

Klaus Schulten: What is a bird seeing in the eye when it detects earth's field? A point? Or does its vision get lighter or darker? That's the kind of question I would like to answer, and only then can we claim we understand how birds navigate.

Our thanks to Klaus Schulten.
Dr. Klaus Schulten has been called 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. Dr. Schulten is a professor of physics, and directs the Theoretical and Computational Biophysics Group of the Beckman Institute at the University of Illinois at Urbana-Champaign.