Magnetoreception molecule found in the eyes of dogs and primates

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Dogs and some primates can sense the earth magnetic field with the help of molecules in their eyes. Credit: L. Peichl

Cryptochromes are light-sensitive molecules that exist in bacteria, plants and animals. In animals, they are involved in the control of the body's

circadian rhythms. In birds, cryptochromes are also involved in the light-dependent magnetic orientation response based on the Earth's magnetic field: cryptochrome 1a is located in photoreceptors in birds' eyes and is activated by the magnetic field. Now researchers from the Max Planck Institute for Brain Research in Frankfurt have also detected cryptochrome 1 in photoreceptors in several mammalian species. Therefore, it is possible that these animals also have a magnetic sense that is linked to their visual system.

The perception of the Earth's magnetic field is used by many animal species for orientation and navigation. A magnetic sense is found in some insects, fish, reptiles, birds and mammals, whereas humans do not appear to be able to perceive the Earth's magnetic field.

The magnetic sense in migratory birds has been studied in considerable detail: unlike a boy scout's compass, which shows the compass direction, a bird's compass recognizes the inclination of the magnetic field lines relative to the Earth's surface. Surprisingly, this inclination compass in birds is linked to the visual system as the magnetic field activates the light-sensitive molecule cryptochrome 1a in the retina of the bird's eye. Cryptochrome 1a is located in the blue- to UV-sensitive cone photoreceptors and only reacts to the magnetic field if it is simultaneously excited by light.

Cryptochrome-distribution among mammals

Together with colleagues from the Ludwig-Maximilians-University Munich, the Goethe University Frankfurt, and the Universities of Duisburg-Essen and Göttingen, Christine Nießner and Leo Peichl from the Max Planck Institute for Brain Research in Frankfurt investigated the presence of cryptochrome 1 in the retinas of 90 species of mammal. Mammalian cryptochrome 1 is the equivalent of bird cryptochrome 1a. With the help of antibodies against the light-activated form of the

molecule, the scientists found cryptochrome 1 only in a few species from the carnivore and primate groups. As is the case in birds, it is found in the blue-sensitive cones in these animals. The molecule is present in dog-like carnivores such as dogs, wolves, bears, foxes and badgers, but is not found in cat-like carnivores such as cats, lions and tigers. Among the primates, cryptochrome 1 is found in the orang-utan, for example. In all tested species of the other 16 mammalian orders, the researchers found no active cryptochrome 1 in the cone cells of the retina.

The active cryptochrome 1 is found in the light-sensitive outer segments of the cone cells. It is therefore unlikely that it controls the animals' circadian rhythms from there, as this control occurs in the cell nucleus which is located a considerable distance away. It is also unlikely that cryptochrome 1 acts as an additional visual pigment for colour perception. The researchers thus suspect that some mammals may use the cryptochrome 1 to perceive the Earth's magnetic field. In evolutionary terms, the blue cones in mammals correspond to the blue- to UV-sensitive cones in birds. It is therefore entirely possible that the cryptochrome 1 in mammals has a comparable function.

Observations of foxes, dogs and even humans actually indicate that they can perceive the Earth's magnetic field. For example, foxes are more successful at catching mice when they pounce on them in a north-east direction. "Nevertheless, we were very surprised to find active cryptochrome 1 in the cone cells of only two mammalian groups, as species whose cones do not contain active cryptochrome 1, for example some rodents and bats, also react to the magnetic field," says Christine Nießner.

Particle-based magnetic compass

One possible explanation for this is that animals can also perceive the

magnetic field in a different way: for example, with the help of magnetite, microscopic ferrous particles in cells. A magnetite-based magnetic sense functions like a pocket compass and does not require any light. Mole rats, which live in lightless tunnel systems, orient using this kind of compass. Birds also have an additional orientation mechanism based on magnetite, which they use to determine their position.

Many fundamental questions remain open in the research on the magnetic sense. Future studies will have to reveal whether the cryptochrome 1 in the blue cones is also part of a magnetic sense in mammals or whether it fulfils other tasks in the retina.

More information: Christine Nießner et al. Cryptochrome 1 in Retinal Cone Photoreceptors Suggests a Novel Functional Role in Mammals, *Scientific Reports* (2016). DOI: 10.1038/srep21848

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