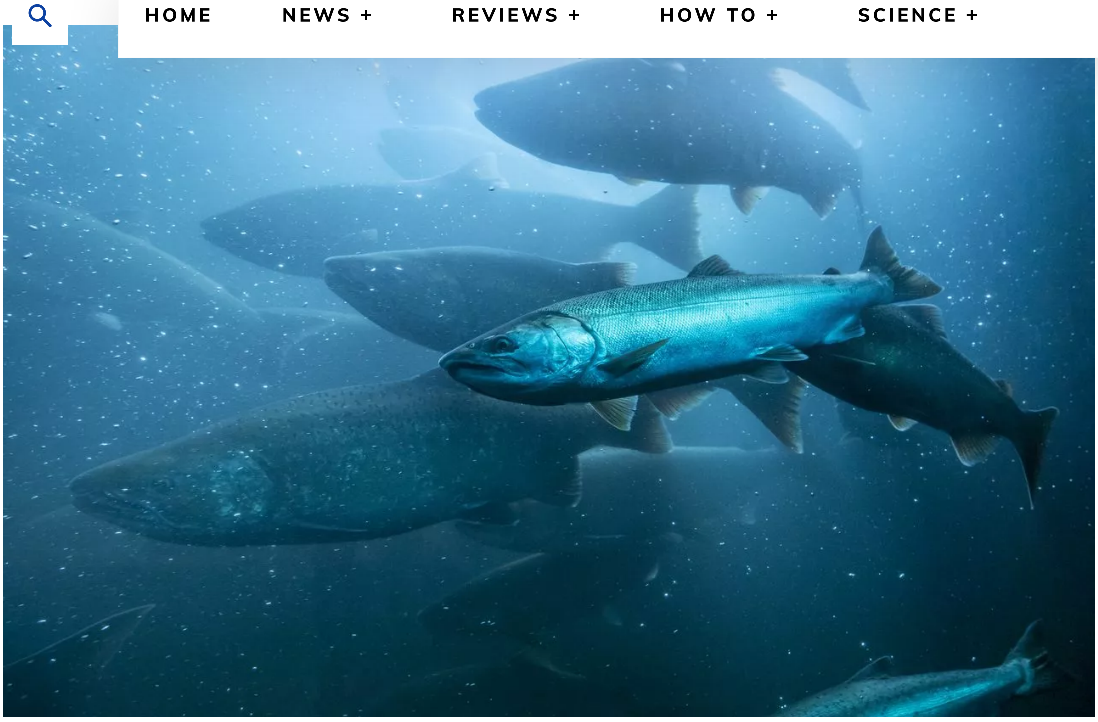

Salmon and many other animals can use the earth's magnetic field to orient themselves during their migrations. (Image: DaveAlan/iStock)

What is it about the amazing orientation skills of some animals? Researchers have now made the "compass needles" of salmon visible for the first time. Genetic studies of the magnetically sensitive cells also provided clues to the history of the development of the "sixth sense" in animals. Apparently it goes deep and goes back to protozoa.

Seeing, hearing, smelling, tasting and feeling – in addition to these usual five senses, some animals have an additional perception ability. For example, it enables migratory birds to find their way thousands of kilometers away, or sea turtles and migratory fish species to return to their birthplaces. This orientation ability is attributed to the ability of so-called magnetoreception: Numerous living beings can be guided by the earth's magnetic field in their navigation.

So far, however, it is only known for a few unicellular organisms how they orient their direction of movement to magnetic fields. "These 'magnetotactic' bacteria have so-called magnetosomes inside them – tiny crystals made of iron compounds that determine the direction in which they move through the earth's magnetic field," says Uwe Hartmann from Saarland University in Saarbrücken. There are already indications that certain body cells with iron oxide particles also function as "compass needles" in higher living beings. However, the exact mechanisms of this sensory-physiological concept in animals are still unclear.

Fishy compass needles revealed

To gain more insight, Hartmann and his colleagues looked at salmon, which are known for their long-distance navigation skills in the sea. Their study used ferromagnetic resonance spectral analysis and microscopy to detect the fish's internal 'compass needles'. The focus was on the so-called olfactory epithelium, which is located on the animals' heads. "For many years, the magnetic properties of this tissue could only be detected by magnetization measurements on larger tissue samples. So far, however, it has never been possible to assign the magnetosomes to individual magnetically sensitive cells," explains the scientist.

That has now changed: "We were able to directly visualize the iron oxide particles, which are just a few nanometers in size, in the olfactory epithelium of salmon," reports Hartmann. The images made it possible for the first time to gain insight into the nature and distribution of the magnetite particles in the cells and to observe their reactions to magnetic forces. The magnetic reversal of the magnetosome is expressed by changing light-dark contrasts in the microscopic images.

involved in the biomineralization of the magnetosomes. Comparisons with genetic information from other living beings then showed that some of these magnetic sense hereditary traits are apparently widespread in animals from different groups – but not only that: some genes have striking similarities to the corresponding hereditary traits in magnetotactic bacteria – so in this case there are surprising homologies between them the higher organisms with a cell nucleus (eukaryotes) and unicellular organisms (prokaryotes).

Research into magnetoreception thus provides evidence of evolutionary links between the two life forms, say the researchers. It is assumed that the prokaryotes arose two to three billion years ago. The first eukaryotes then developed from them around 1.2 to 1.8 billion years ago. As the study results suggest, prokaryotic genes for magnetoreception were apparently also inherited by eukaryotic cells. Consumption could have played a role here: Within the framework of the so-called endosymbiont theory, it is assumed that the eukaryotes developed their complex organelle system by absorbing prokaryotes. The results now make it possible that the magnetoreception system could have passed from prokaryotes to eukaryotes in this way.

Source: Saarland University, specialist article: PNAS: 10.1073/pnas.2108655119

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