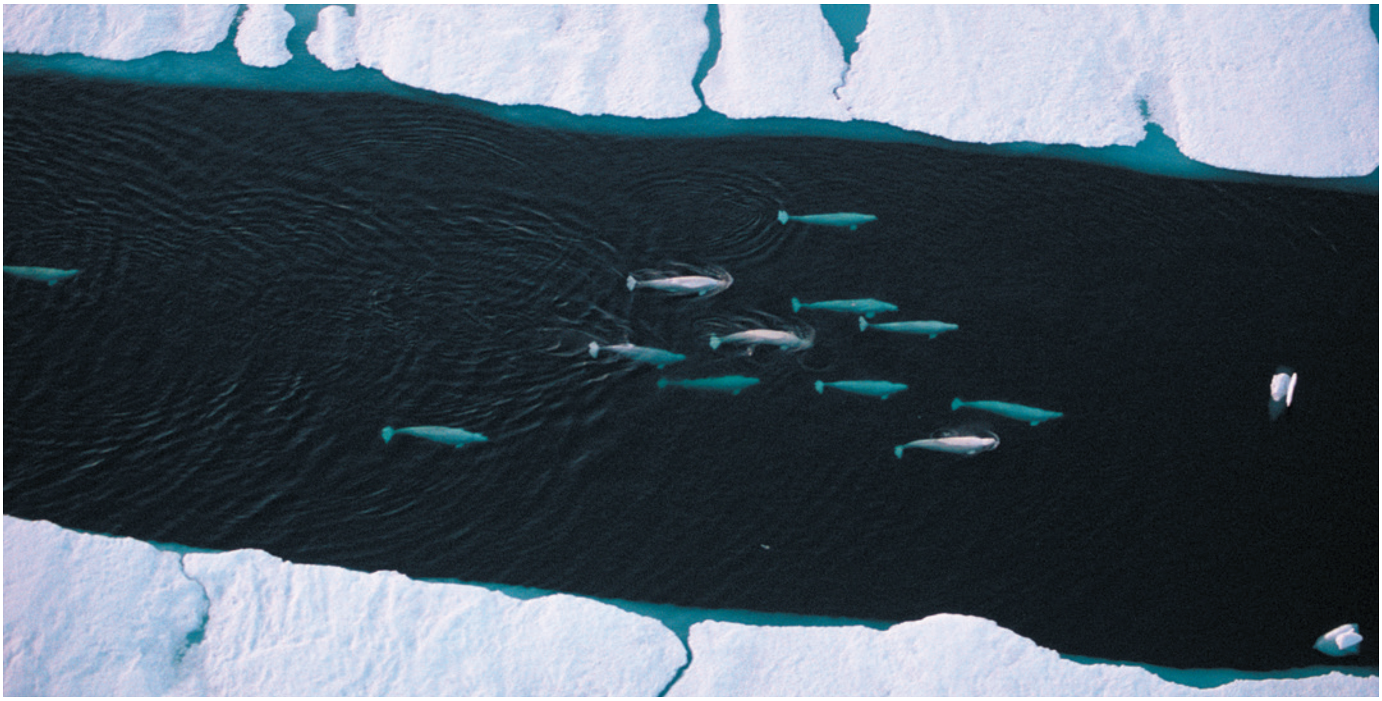

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Beluga whales are among the species that are thought to use Earth's weak magnetic field for navigation.

BIOCHEMISTRY

Long-sought 'biocompass' discovery claimed

Protein complex offers explanation for how animals sense Earth's magnetic pull.

BY DAVID CYRANOSKI

In the cells of fruit flies, Chinese scientists say that they have found a biological compass needle: a rod-shaped complex of proteins that can align with Earth's weak magnetic field.

The biocompass — whose constituent proteins exist in related forms in other species, including humans — could explain a long-standing puzzle: how animals such as birds and insects sense magnetism. It might also become an invaluable tool for using magnetic fields to control cells, report researchers led by biophysicist Xie Can at Peking University in Beijing, in a paper published on 16 November in *Nature Materials* (S. Qin *et al. Nature Mater.* http://doi.org/89v; 2015).

"It's an extraordinary paper," says Peter Hore, a biochemist at the University of Oxford, UK. But Xie's team has not shown that the complex actually behaves as a biocompass inside living cells, nor explained exactly how it senses magnetism. "It's either a very important paper or totally wrong. I strongly suspect the latter," says David Keays, a neuroscientist who studies magnetoreception at the Institute of Molecular Pathology in Vienna.

Many organisms — ranging from whales to butterflies, and termites to pigeons — use Earth's magnetic field to navigate or orient themselves in space. But the molecular mechanism behind this ability, termed magnetoreception, is unclear.

Some researchers have pointed to magnetically sensitive proteins called 'cryptochromes', or 'Cry'. Fruit flies lacking the proteins lose their sensitivity to magnetic fields, for example. But the Cry proteins alone cannot act as a compass, says Xie, because they cannot sense the polarity (north–south orientation) of magnetic fields.

Others have suggested that iron-based minerals might be responsible. Magnetite, a form of iron oxide, has been found in the beak cells of homing pigeons. Yet studies suggest ▶

that magnetite plays no part in pigeon magnetoreception.

Xie says that he has found a protein in fruit flies that both binds to iron and interacts with Cry. Known as CG8198, it binds iron and sulfur atoms and is involved in fruit-fly circadian rhythms. Together with Cry, it forms a nanoscale 'needle': a rod-like core of CG8198 polymers with an outer layer of Cry proteins that twists around the core.

Using an electron microscope, Xie's team saw assemblies of these rods orienting themselves in a weak magnetic field in the same way as compass needles. Xie gave CG8198 the new name of MagR, for magnetic receptor.

The discovery offers scientists the prospect of using magnetic fields to control cells. Over the past decade, scientists have commandeered the light-sensing capacity of some proteins to manipulate neurons, usually by inserting a fibre-optic cable directly into the brain — a tool called optogenetics. But magnetosensing proteins have the advantage that they could be manipulated by magnetic fields outside the brain.

Zhang Sheng-jia, a neuroscientist at Tsinghua University in Beijing, claims to have already demonstrated this 'magnetogenetic' capability. In September, he provided a surprise preview of Xie's work when he published a paper reporting use of the biocompass to manipulate neurons in worms (X. Long *et al. Sci. Bull.* http://doi.org/883; 2015). Xie and others complained that Zhang's early publication violated a collaboration agreement between the two researchers — the details of which are disputed — and asked for it to be retracted. In October, Zhang was fired from his university, a decision that he is contesting (see *Nature* http://doi.org/882; 2015).

"If MagR is the real magnetoreceptor, I'll eat my hat."

Xie says that in April, he submitted a Chinese patent application that includes the use of magnetogenetics and the protein's magnetic capacity to manipulate large molecules. He is also starting to look at the structure of MagR proteins in other animals, including humans. Variants in the human version of MagR might even relate to differences in people's sense of direction, he suggests.

SCEPTICAL VOICES

Other scientists are not convinced that the biological needles function like compasses in living organisms. Xie's team has shown that MagR and Cry are produced in the same cells in pigeon retinas — the birds' proposed magnetoreception centre — but MagR and Cry are found in many cells, says Keays. "With such a small amount of iron, one has to ask whether *in vivo*, at physiological temperatures, MagR is capable of possessing magnetic properties at all," he says. "If MagR is the real magnetoreceptor, I'll eat my hat."

Xie hopes that others will strengthen his case with further experiments, such as inactivating the gene for MagR in certain fruit-fly tissues to see whether it affects the animals' sense of direction. He published without doing this work, he says, because he just wanted to report the findings, which he has been working on for six years.

The lack of an exact mechanism for how the protein complex senses magnetism, or how any signal it sends might be processed by the brain, gives some researchers pause. MagR's biocompass activity might simply be the result of experimental contamination, says Michael Winklhofer, a magnetism specialist and Earth scientist at Ludwig Maximilian University of Munich in Germany. He is planning experiments to follow up on Xie's team's findings. If it holds up, says Winklhofer, then the discovery of MagR "appears to be a major step forward towards unravelling the molecular basis of magnetoreception". ■

PHYSICS

Space test for long-awaited gravitational-wave detector

Europe's LISA Pathfinder spacecraft has two metal cubes at its heart, which it will attempt to isolate from every force except for gravity.

BY ELIZABETH GIBNEY

There is a lot riding on the LISA Pathfinder mission, an ambitious effort to test whether intricate technology designed to detect ripples in space-time can be deployed in space.

Scheduled to launch on 2 December, the spacecraft is a long-awaited test-drive for a future €1-billion (US$1.1-billion) space observatory planned by the European Space Agency (ESA). The follow-up mission would track the largest objects in the Universe, including mergers between supermassive black holes and collisions between galaxies, by the space-time ripples that they create.

First predicted by Albert Einstein almost exactly 100 years ago as part of his general theory of relativity (see nature.com/relativity100), such gravitational waves have never been observed directly — let alone used to study the cosmos. There are already Earth-based observatories hunting these waves, but a space-based one would search for waves at the opposite end of the spectrum (see *Nature* **525,** 301–302; 2015). "It's like having a radio telescope as well as an optical one," says Karsten Danzmann, director of the Max Planck Institute for Gravitational Physics in Hanover, Germany, and co-principal investigator for the Pathfinder mission. "The part of the Universe you see is completely different."

The final space-based observatory will try to spot the stretching and compressing of space by bouncing laser beams between three masses floating in freefall, each separated from the others by some 5 million kilometres. Because the masses would be protected from all other external forces, only a gravitational wave should disrupt the synchrony of their falling motion — a disturbance that would affect laser frequency.

The LISA Pathfinder (named after the Laser Interferometer Space Antenna, the concept behind the gravitational-wave observatory) is a smaller-scale test of this ultimate plan. With a pricetag of €400 million, it uses just two masses — each a 2-kilogram cube of gold and platinum — separated by a mere 38 centimetres, which allows them to fit inside the same spacecraft.

Unlike that of the observatory that it is designed to test-drive, this set-up is not sensitive enough to detect gravitational waves — instead, its purpose is to show that the masses can be completely isolated, and that any deviations in their relative motion can be measured with picometre accuracy. "We're missing out