Columbarian Columbuses

WHERE would people be without magnetic compasses? The short answer is: lost. By giving human beings a sixth sense—an ability to detect the hitherto invisible magnetic field of the Earth—the compass proved one of the most important inventions ever. It let sailors navigate without sight of the night sky. And that led to the voyages of discovery, trade and conquest which created the political geography of the modern world.

Imagine, then, what animals which had their own, built-in compasses could achieve. They might spend their summers doing the English Season in Glyndebourne or Henley, and then overwinter in the warmth of Mombasa. They might strike out, like intrepid pioneers, from Angola to Anchorage. They might even, if truly gripped by wanderlust and a hatred of the darkness, live in near-perpetual daylight by migrating from Pole to Pole.

In this section

Reprints

Related topics

And that is just what some birds do. Swallows travel between Europe and Africa. Northern wheatears fly from Africa to Alaska, and back. Arctic terns each year make the journey from one end of the planet to the other. And they can do it, at least in part, because they do have a magnetic sense denied to humans.

The most familiar avian navigation trick is that pulled off by homing pigeons. As a consequence pigeons have often found themselves at the sharp end of investigations about how bird navigation in general, and magnetic sense in particular, actually work. That pigeons have such a sense was shown more than 40 years ago, by William Keeton of Cornell University, in upstate New York, who attached magnets to pigeons to see if they could still home. They could not, though birds fitted with non-magnetic dummies managed perfectly well. Since then, experiments on other species have shown magnetic sensitivity is common among birds. What these experiments have not shown, however, is how the birds manage it.

See it? Hear it? Smell it?

There are two theories. One is that the magnetic sensors are grains of magnetite, a form of iron oxide which, as its name suggests, is easily magnetised. The other is that the Earth's magnetic field affects a particular chemical reaction in the retina in a way that reaches into the arcane depths of quantum mechanics.

The magnetite hypothesis concentrates on birds' beaks. Magnetite grains are common in living things, and are known to be involved in magnetic sensing in bacteria. In birds they are particularly abundant in the beak. So last year David Keays of the Institute of Molecular Pathology, in Vienna, dissected the beaks of nearly 200 unfortunate pigeons, to find out more.

What he discovered was not encouraging. There were, indeed, lots of magnetite grains. But he had expected they would congregate in some sort of specialised sensory cell akin to the taste buds of the tongue or the hair cells of the ear. Instead, he found that the beak's magnetite is mostly in macrophages. These are cells whose job is to wander around amoeba-like, chewing up bacteria and debris from other body cells as they go. Not, then, likely candidates as magnetic sensors.

Other experiments, though, do suggest the beak is involved. The nerve that connects it to the brain is known as the trigeminal. When Dominik Heyers and Henrik Mouritsen of Oldenburg University, in Germany, cut the trigeminals of reed warblers the birds' ability to detect which way was north remained intact. They did, however, lose their sense of magnetic dip (the angle the Earth's field makes with the ground). Dip indicates latitude, another important part of navigation.

To confuse matters further, some people accept Dr Keays's interpretation of what is going on in the beak, but think that the relevant magnetite grains are elsewhere—in the hair cells of the ear, which are also rich in iron oxide. If they are right, then from the birds' point of view they are probably "hearing" the magnetic signal.

The main alternative to the nasal-magnetite hypothesis, though, is not that birds hear magnetic fields, but that they see them. One line of evidence for this is that part of a bird's brain, called cluster N, which gets its input directly from the eyes, seems to be involved in magnetic sensing. Experiments Dr Mouritsen's team conducted on robins showed that destroying cluster N destroys a bird's north-detecting sense (they did not look at the question of dip), and other experiments, on meadow pipits, show that cells in cluster N are far more active when the birds are using their magnetic sense than when they are not.

The problem with this idea is that birds' eyes do not have magnetite in them. If they do house magnetism detectors, those detectors must be something else.

That something, according to a hypothesis advanced by Klaus Schulten, who works at the University of Illinois at Urbana-Champaign, is a type of retinal protein called a cryptochrome. When hit by light, a cryptochrome produces pairs of molecules called free radicals that are electrically neutral but have unpaired electrons in them. Electrons are tiny magnets, so they tend to attract each other and pair up in a way that neutralises their joint magnetic fields. Unpaired electrons, however, remain magnetic, and thus sensitive to the Earth's field.

Moreover, because the unpaired electrons in the free radicals were originally paired in the molecule that split to form the radicals, quantum mechanics dictates that these electrons remain "entangled". This means that however far apart they move, what happens to one affects the other's behaviour. Calculations suggest the different ways the two radicals feel the Earth's field as they separate is enough to change the way they will react with other chemicals—including ones that trigger nerve impulses, and that, via entanglement, they can "transmit" this information to each other, and thus affect each other's reactions.

This, the calculations indicate, would be enough for a bird's brain to interpret the magnetic field. It would probably see a pattern of spots before its eyes, which would remain stationary as it scanned its head from side to side. And some birds do, indeed, scan their heads this way when assessing the direction of magnetic north.

It is possible, of course, that both hypotheses are right, and that birds have two magnetic senses, with one perhaps concentrated on north detection and the other on detecting dip. But there is something particularly poetic about the idea that even part of this mysterious sixth sense depends on a still-more-mysterious quantum effect—one that Einstein himself described as “spooky action at a distance”.