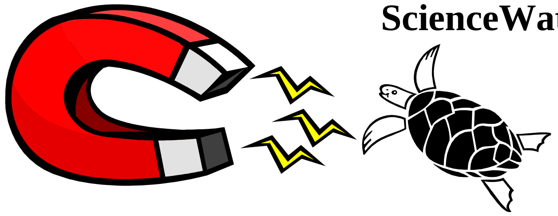
ScienceWatch – Animal Magnetism



When animals migrate the need to take the right path is so necessary for survival that several mechanisms have evolved to point migrants in the right direction. Indeed, many experiments with various animals have shown that they may use a compass system based on the sun, stars, the earth's magnetic field or they may use landscape cues to guide them. At any given time they may use one signal or another, or even depend upon a combination of signals. While other cues may be temporarily obscured, the earth's magnetic field is ever-present so a magnetic compass can be very handy. In fact, magnetite particles have been found in organisms as different as birds and bacteria. However, exactly how the compass is used and where magnetoreceptive cells reside in the brain has been more difficult to determine. Two studies in the October 12, 2001 issue of *Science* attack these questions.

Loggerhead turtles (*Caretta caretta*) from eastern Florida perform one of nature's longest migrations. Guided by the brighter moonlit sky, loggerhead hatchlings immediately run toward the water. Once they enter the ocean they begin a 5-10 year journey of approximately 10,000 miles in the North Atlantic gyre, a circular ocean current flowing clockwise around the Sargasso Sea. From the eastern Florida coast turtles head northeast toward Europe, then south along the African coast, west across the South Atlantic and finally, back to the Florida coast (see solid arrows of map).

During this time they feed in the warm, rich waters of the gyre before returning to their birthplace on the Florida coastline where the females lay their eggs. It is extremely important for turtles to maintain the proper compass heading because other currents split off from the gyre (dotted arrows of map), sending them out of their normal range with little chance to return.

Now a team headed by marine biologist Kenneth Lohmann from the University of North Carolina has shown that the turtles perform their daunting navigational feat by responding to regional variations in the earth's magnetic field. Interestingly, at birth the turtles not only posses an innate ability to detect magnetic field variations, but they can respond by making course alterations that would keep them in the gyre without ever having seen the ocean.

Lohmann and his team collected turtles as they were hatching in their nests. Seventy-nine hatchlings were placed in the dark in a small pool surrounded by a computerized coil system, which was used to control the magnetic field in which each turtle swam. They were then exposed to one of three different magnetic fields. Each magnetic field replicated one of several they would experience at critical points in their migration (see map stars) where they must change direction or lose the gyre. Turtles exposed to a field replicating one that exists offshore near northern Florida swam east-southeast. Those exposed to a field like one near the northern edge of the gyre swam south. Others exposed to a field like one at the southern edge of the gyre swam west-northwest. Thus, lacking any prior migratory experience, each group headed in a direction that kept them on their migratory path and prevented them from being swept out of the gyre.

According to the scientists, the best explanation for these results is that the turtles inherit a magnetic map of the North Atlantic that keeps them on course because they respond in particular ways to changing magnetic fields. Forty years ago geologists showed that the earth's magnetic field periodically flip-flops. No one knows why this happens, but when it does, magnetic "north" becomes magnetic "south", and then back again. During the last 1 million years this flip-flop has happened every 30,000 years, on average. In spite of that the turtles still know where they are going. Evidently, they must alter their inherited program as the field reversal occurs.

A second study in the same issue of *Science* shows how these inherited magnetic responses may operate in the brain. Pavel Němec at the Charles University in Prague, Czech Republic, and colleagues at the J. W. Goethe University in Frankfurt, Germany, have discovered what part of the brain of Zambian mole rats (*Cryptomys anselli*) is responsive to magnetic field stimulation. The mole rat is not migratory, but it lives its life in underground tunnels that may extend up to 200 meters (600 feet). At the end of the tunnel the mole rats build a nest that is always positioned in a southerly direction.

Instead of trying to home in on electrically active neurons, this team had the novel approach of looking for areas of the brain that were actively synthesizing neural chemicals when mole rats were orienting themselves under stimulation by a strong magnetic field. The researchers put 16 rats in an enclosure and challenged them to build nests in one of three conditions: the natural geomagnetic field; a field that was periodically rotated by 120^o; and a weak, shielded field.

After one hour, slices of the animal's brains were assayed for neuronal activity. Activity was low in the brains of animals kept in the shielded field. But those under an active magnetic field showed strong neuronal activity in an area of the brain known as the superior colliculus. This area of the brain is a neural relay station known to be involved in the collection of spatial stimuli and control of orientation behavior.

This finding is a breakthrough because it is the first to identify an area of the brain that is processing sensory information from the cells that detect the magnetic field. With this information scientists can begin to put together a coherent story on the nature of the magnetosensory system animals use for migration. Perhaps by then we will learn how the turtles, and presumably others, survive the magnetic field flip-flops.

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