Животный магнетизм
Content

• Examples of magneto reception in animal world
• Known mechanisms of magneto reception
• Future applications of magneto reception
Which information animals can receive from Earth magnetic field

Two types of information:
1. Direction
2. Position
Artificial magnetic field influence “heading” behavior in birds
<table>
<thead>
<tr>
<th>Animal Group</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mollusks</td>
<td></td>
</tr>
<tr>
<td>Snails</td>
<td>1 species</td>
</tr>
<tr>
<td>Arthropods</td>
<td></td>
</tr>
<tr>
<td>Crustacean</td>
<td>5 species</td>
</tr>
<tr>
<td>Insects</td>
<td>9 species</td>
</tr>
<tr>
<td>Vertebrates</td>
<td></td>
</tr>
<tr>
<td>Cartilaginous fish</td>
<td>1 species</td>
</tr>
<tr>
<td>Bony fish</td>
<td>4 species</td>
</tr>
<tr>
<td>Amphibians</td>
<td>2 species</td>
</tr>
<tr>
<td>Reptiles</td>
<td>2 species</td>
</tr>
<tr>
<td>Birds</td>
<td>20 species</td>
</tr>
<tr>
<td>Mammals</td>
<td>5 species</td>
</tr>
</tbody>
</table>

Maybe even humans - unconsciously
Magnetic Alignment in Carps: Evidence from the Czech Christmas Fish Market
Plose One, Dec 2012
Papers about magneto reception

Good paper:

• Shows direction preference related to magnetic field
Papers about magneto reception

Good paper:

• Shows direction preference related to magnetic field

AND

• Shows change of preference when magnetic field is changed artificially (whereas other parameters are unchanged)

Some papers only show direction preference and speculate that it is related to magnetic field
Magnetic alignment in grazing and resting cattle and deer

Sabine Begall*, †, Jaroslav Červený‡, §, Julia Neef*, Oldřich Vojtěch ‡, ¶, and Hynek Burda*

Author Affiliations

Edited by Simon A. Levin, Princeton University, Princeton, NJ, and approved July 17, 2008 (received for review April 15, 2008)

The mystery of the magnetic cows

Researchers disagree over replication of study showing that cows line up with Earth's magnetic field.

Daniel Cressey
Magnetoception in mammals

Nest of Zambian mole rat (*Fukomys amatus*)

Positions of nests (a) in the local geomagnetic field: $n = 21$, $\alpha = 143^\circ$, $r = 0.79$, $p < 0.001$, (b) with magnetic north turned to geographic WSW: $n = 16$, $\alpha = 32^\circ$, $r = 0.74$, $p < 0.001$, and (c) with magnetic north turned to geographic S: $n = 40$, $\alpha = 325^\circ$, $r = 0.46$, $p < 0.001$. The arrows represent the respective mean vectors.

Experientia 46 (1990), Birkhäuser Verlag, CH-4010 Basel/Switzerland
Magnetoception in mammals

Big brown bat *Eptesicus fuscus*

Heading directions at 5 km after release 20 km north of the home roost (to south; black arrow).

Red, anticlockwise (ACW) rotation of magnetic field by 90° with respect to north; blue, clockwise (CW) rotation of magnetic field by 90°; green, controls (no rotation of magnetic field)
Bat orientation using Earth’s magnetic field

Bats famously orientate at night by echolocation, but this works over only a short range, and little is known about how they navigate over longer distances. Here we show that the homing behaviour of *Eptesicus fuscus*, known as the big brown bat, can be altered by artificially shifting the Earth’s magnetic field, indicating that these bats rely on a magnetic compass to return to their home roost. This finding adds to the impressive array of sensory abilities possessed by this animal for navigation in the dark.

For some taxa, navigation behaviour can be readily investigated in the laboratory. To study the wide-ranging navigation of bats, however, their flight path needs to be tracked in a natural setting. Limitations of the available technology make this a labour-intensive process, so bat navigation is relatively poorly understood compared with that of other animals.

We used radio telemetry to track two brown bats released 20 km north of their home roost (for methods, see supplementary information). A control group released from this site headed in a direction significantly towards home (see supplementary information) at 5 km from the release site (Fig. 1a).

To test whether bats use the Earth’s magnetic field, we exposed two groups of bats to a rotated magnetic field, one 90° clockwise and one 90° anticlockwise with respect to magnetic north, for a period from 45 min before to 45 min after sunset. This also allowed us to test whether the Earth’s magnetic field was being used in conjunction with other cues, such as the sunset or stars (see supplementary information).

The headings of the clockwise group were significantly oriented in an easterly direction (90°) at 5 km from the release site, whereas the anticlockwise group followed significantly in a westerly (270°) direction, the two groups showed a significant difference (Fig. 1b). These different initial orientations of the groups indicate that they may have been using a sunset-calibrated magnetic compass.

Some experimental bats corrected and homed during the approximately 45° from their initial orientation away from home (Fig. 1c). Although such behaviour has previously been unknown in bats, homing pigeons can correct and return home after an initial deviation when clockshifted. We suggest that the deflected bats that nevertheless return home during the same period recognize a mismatch between the direction they are flying and their navigational map.

Besides the application described here to measure bat navigation, radio telemetry has also been used to investigate migration in insects. The possibility of transmitting such radio signals to low-orbiting satellites should open up field studies on the orientation, navigation and migration of small, wide-ranging animals.

Richard A. Holland*, Keeper Thorup† (†S. Maarten J. Venhoff), William W. Cochran‡, Martin Wielkis*  

*Department of Ecology and Evolutionary Biology, Princeton University, Princeton, New Jersey 08544, USA  
‡Biology Department, Princeton University, Princeton, New Jersey 08544, USA  
†Department of Integrative and Comparative Biology, University of Arizona, Tucson, Arizona 85721, USA  
‡Research Station, National Biological Program of Canada, University of Washington, Seattle, Washington 98195, USA  
§Department of Zoology, University of Oxford, South Parks Road, Oxford, OX1 3PS, UK

Figure 1: Heads and tracks of homing bats. a, Heading directions at 5 km after release 20 km north of the home roost (to south, black arrow). Arrowsheads, directions for individual bats; arrows, mean direction for the group. Bold, anticlockwise (ACW) rotation of magnetic field by 90° with respect to north; blue, clockwise (CW) rotation of magnetic field by 90°; green, controls (no rotation of magnetic field). Orientation was significantly southerly in controls (Y test, 1987, U = 2.612, P = 0.0072); westerly in ACW bats (Y test, 2080, U = 1.957, P = 0.0525); and easterly in CW bats (Y test, 1980, U = 2.66, P = 0.0082). Headings differed significantly between the three groups (Watson–Williams F tests; P = 0.00003; pairwise CW vs control, P = 0.0384). CW vs control, P = 0.032; ACW vs CW, P = 0.0064; ACW vs control, P = 0.0073; P = 0.0031). b, c, Control (b) and experimental tracks (c) of bats, with different dotted and dashed lines for individual bats (n = 5 in each group). Colours indicate direction of rotation of magnetic field, as in a. R, release site; H, home.
Could Human being feel magnetic field?

Geomagnetic storm:
Moderate 50-100 nT
Intense 100-250 nT
Super-storm >250nT

Earth's surface ranges from 25 to 65 uT

“В настоящее время отделение "МРТ-технологии" МТЦ СО РАН оснащено современными томографами:
1,5 T Achieva фирмы Philips и 0,4 T фирмы Hitachi”
Magneto sensor systems

How does it work?
Magneto sensor system I - cryptochromes

![Diagram of a magneto sensor system with labels](image)

**Graph a:**
- Preference index vs. wavelength
- Full spectrum, >500 nm, >420 nm
- Values: 15, 12, 12
- Statistical significance markers: ****

**Graph b:**
- Preference index vs. genotype
- Canton-S, w;Canton-S, Oregon-R, Berlin-K
- Values and error bars for each genotype
- Statistical significance markers: ****, **, *, **

**Legend:**
- Full spectrum
- >500 nm
- >420 nm
- >400 nm
Magneto sensor system I - cryptochromes
Magneto sensor systems

Main molecules - cryptochromes, in birds localized in retina
Magnetosensor systems

I

Main molecules - cryptochromes,
In birds localized in retina

II

Main molecule – Fe₃O₄ ("magnetite")
In bacteria localized in magnetosomes
Magneto sensor system II

Localization of Fe$_3$O$_4$ in birds

1. Upper beak

2. Inner Ear Lagena

Clusters of iron-rich cells in the upper beak of pigeons are macrophages not magnetosensitive neurons.

Fig. 3. Vestibular apparatus of inner ear. Neurons are found in the ampullary organs (blue), macular regions (green), and lagena (yellow).
Photomicrographs and Anatomical Tracings for c-Fos-Positive Neurons
Single-cell extracellular responses from vestibular nuclei during magnetic field stimulation
Why studying magneto reception?
Why studying magneto reception?
Magnetoreception: an unavoidable step for plant evolution?

Andrea Occhipinti¹, Angelo De Santis², Massimo E. Maffei¹, ✉