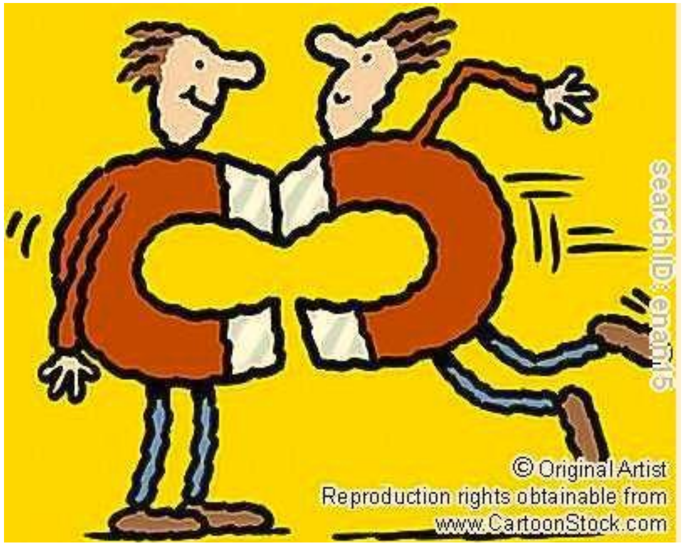
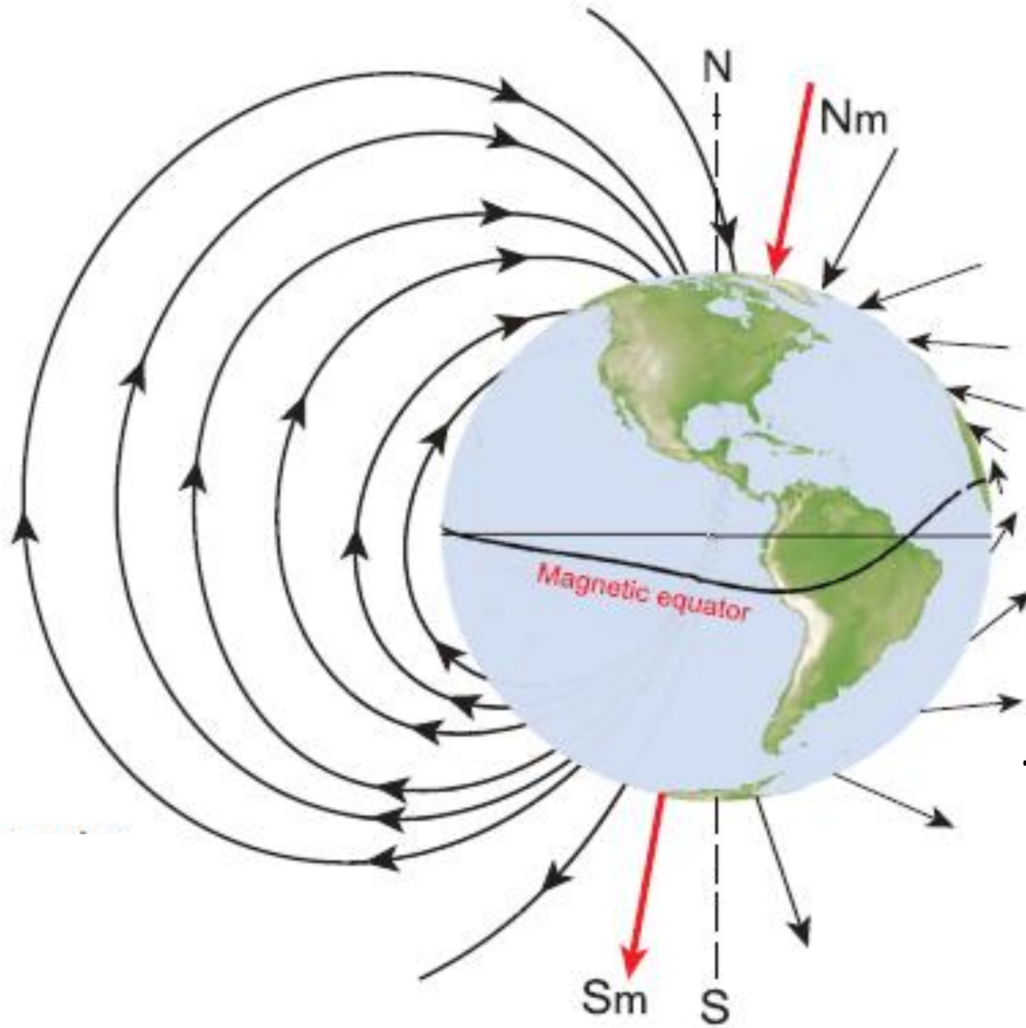


Животный магнетизм

Content

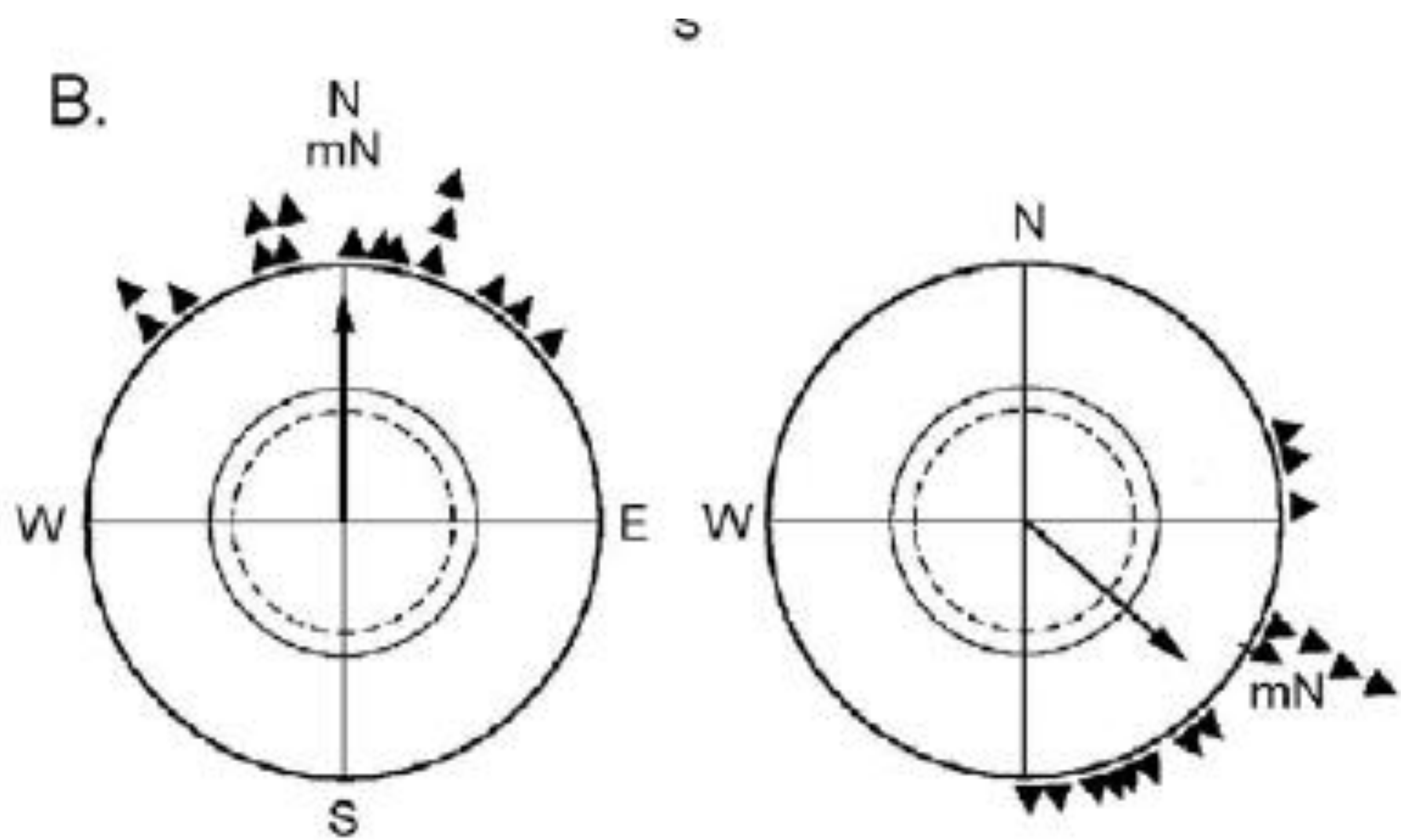
- Examples of magneto reception in animal world
- Known mechanisms of magneto reception
- Future applications of magneto reception

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

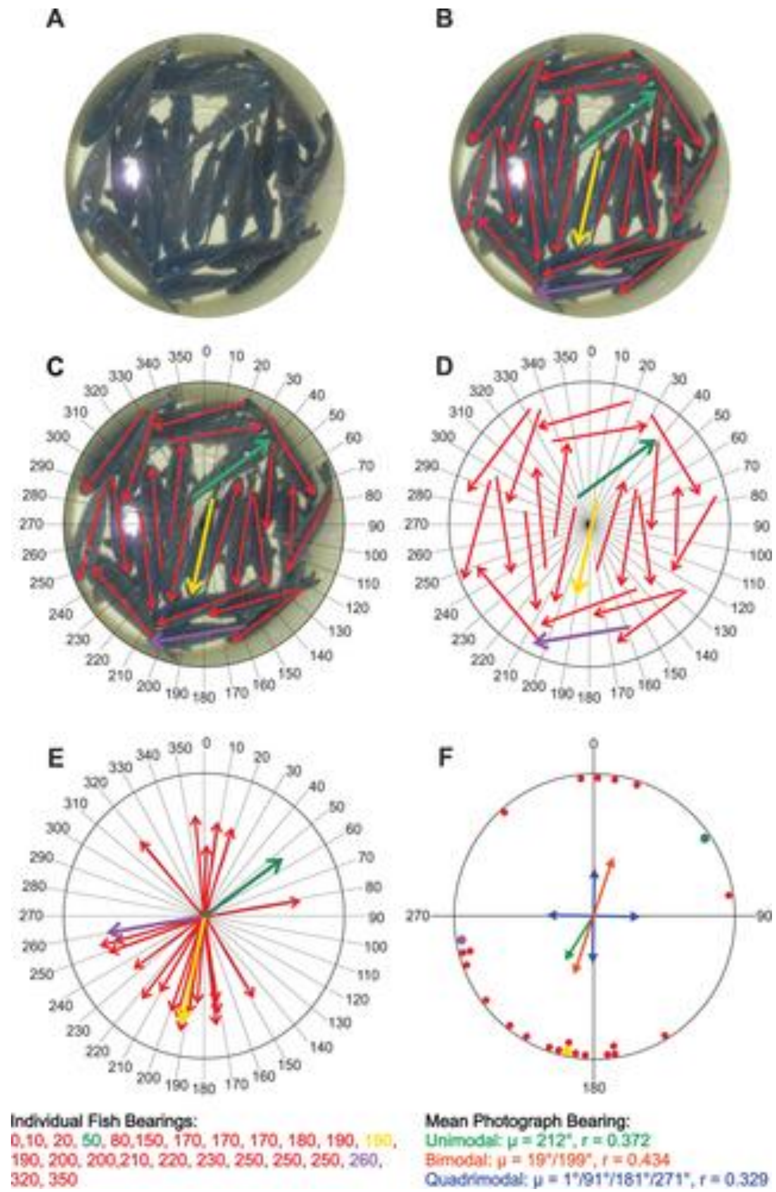


Animal Group	
Mollusks	
Snails	1 species
Arthropods	
Crustacean	5 species
Insects	9 species
Vertebrates	
Cartilageous fish	1 species
Bony fish	4 species
Amphibians	2 species
Reptiles	2 species
Birds	20 species
Mammals	5 species

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

CrossMark click for updates

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)

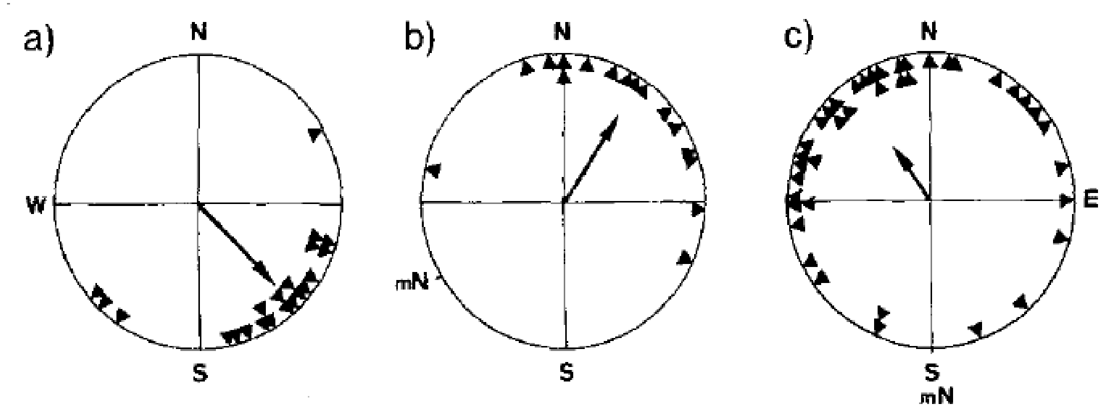
NATURE | NEWS

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



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

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

Nest of Zambian mole rat (*Fukomys amatus*)

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)

Villa (eds Sánchez-Cordero, V. & Medellín, R. A.) 163–186 (Instituto de Biología e Instituto de Ecología, UNAM, Mexico, 2005).
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Competing financial interests: declared none.
doi:10.1038/444701a

NAVIGATION

Bat orientation using Earth's magnetic field

Bats famously orientate at night by echolocation[1], but this works over only a short range, and little is known about how they navigate over longer distances[2]. 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[3]. 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[2].

We used radio telemetry from a small aircraft[4] to track big brown bats displaced 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[5] (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 moved significantly in a westerly (270°) direction; the two groups showed a significant difference (Fig. 1a). These different initial orientations of the groups indicate that they may have been using a sunset-calibrated magnetic compass[5,6].

Some experimental bats corrected and homed during the same night, despite being initially orientated away from home (Fig. 1b, c). Although such behaviour has previously been unknown in bats, homing pigeons can correct and return home after an initial deviation when clock-shifted[7]. We suggest that the deflected bats that nevertheless home during the same night 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[8]. 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.

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¶Illinois Natural History Survey, Champaign-Urbana, Illinois 61820, USA

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Competing financial interests: declared none.
doi:10.1038/444702b

BRIEF COMMUNICATIONS ARISING online
www.nature.com/bca see *Nature* contents.

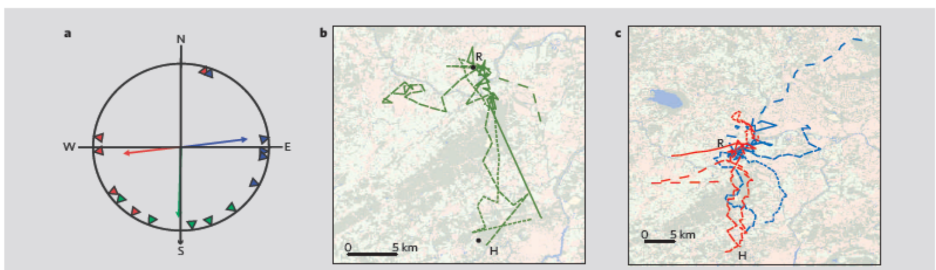


Figure 1 | Headings and tracks of homing bats. **a**, Heading directions at 5 km after release 20 km north of the home roost (to south; black arrow). Arrowheads, directions for individual bats; arrows, mean direction for the group. Red, anticlockwise (ACW) rotation of magnetic field by 90° with respect to north; blue, clockwise (CW) rotation of magnetic field by 90°; green, controls (no rotation of magnetic field). Orientation was significantly southerly in controls (V test, 180°, $U=2.862$, $P=0.0072$); westerly in ACW bats (V test, 270°, $U=1.973$, $P=0.023$); and easterly in CW bats (V test, 90°, $U=2.66$, $P=0.002$). Headings differed significantly between the three groups (Watson–Williams 3-sample test: $F=16.808$, $P=0.00033$; pairwise: CW vs control, $F=23.774$, $P=0.001$; ACW vs control, $F=6.733$, $P=0.032$; ACW vs CW, $F=23.503$, $P=0.001$). **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**

vs

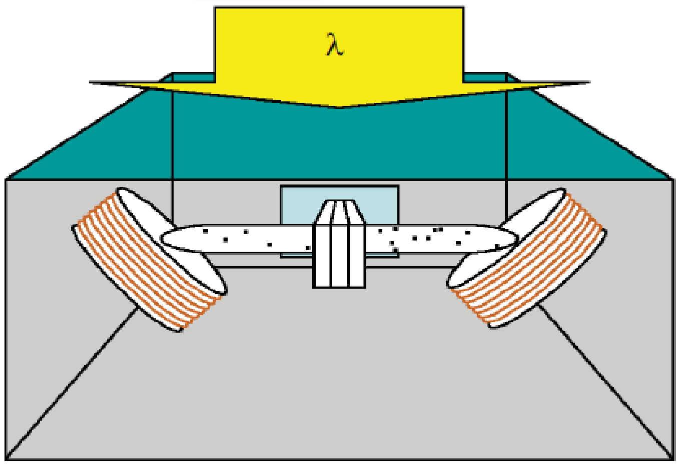
“В настоящее время отделение "МРТ-технологии" МТЦ СО РАН оснащено современными томографами:
1,5 Т Achieva фирмы Philips и **0,4 Т** фирмы Hitachi”

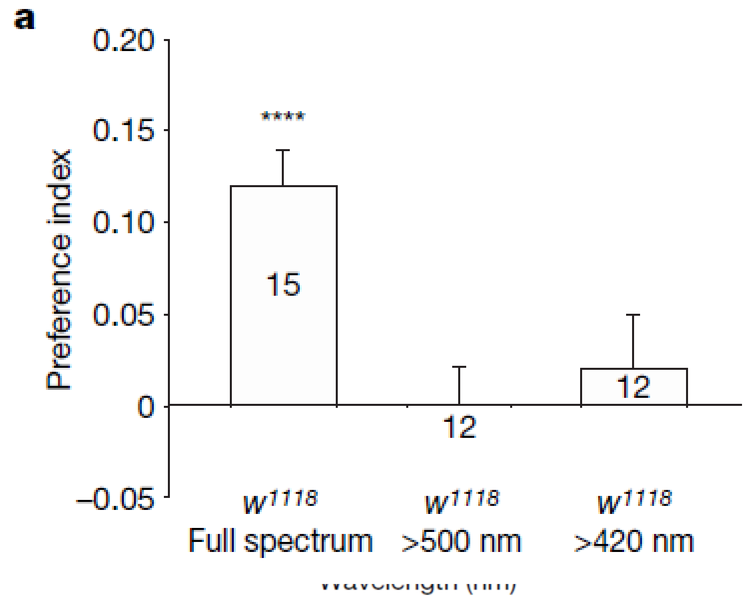
Magneto sensor systems

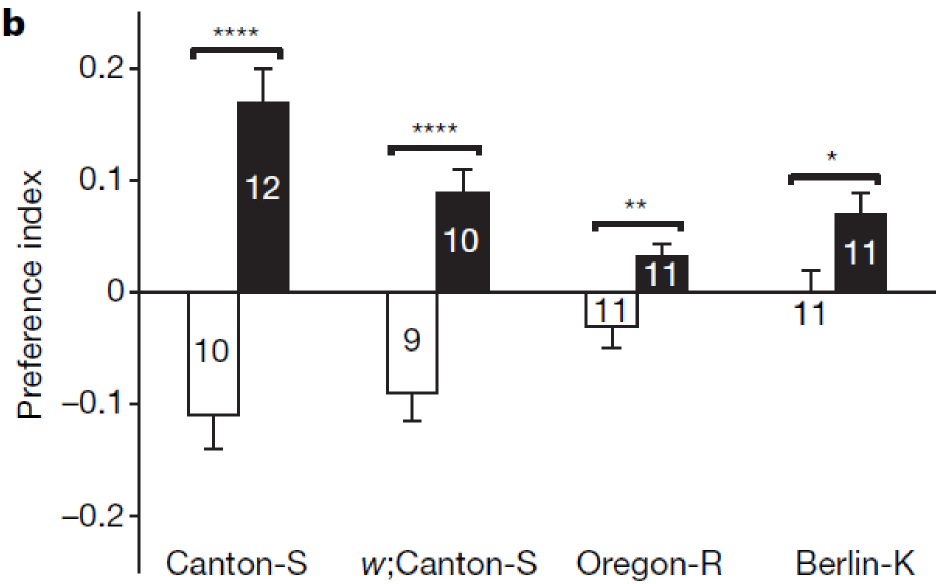
How does it work?

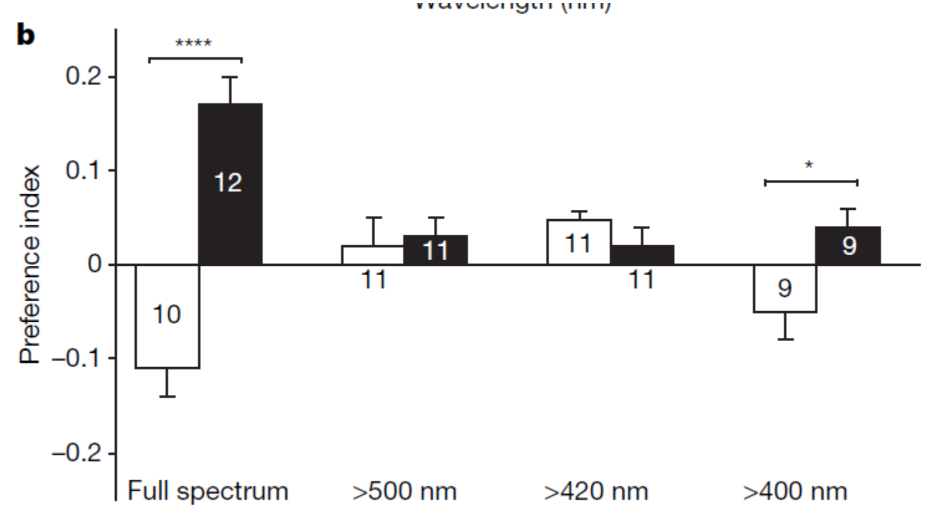
Magneto sensor system I - cryptochromes

Test

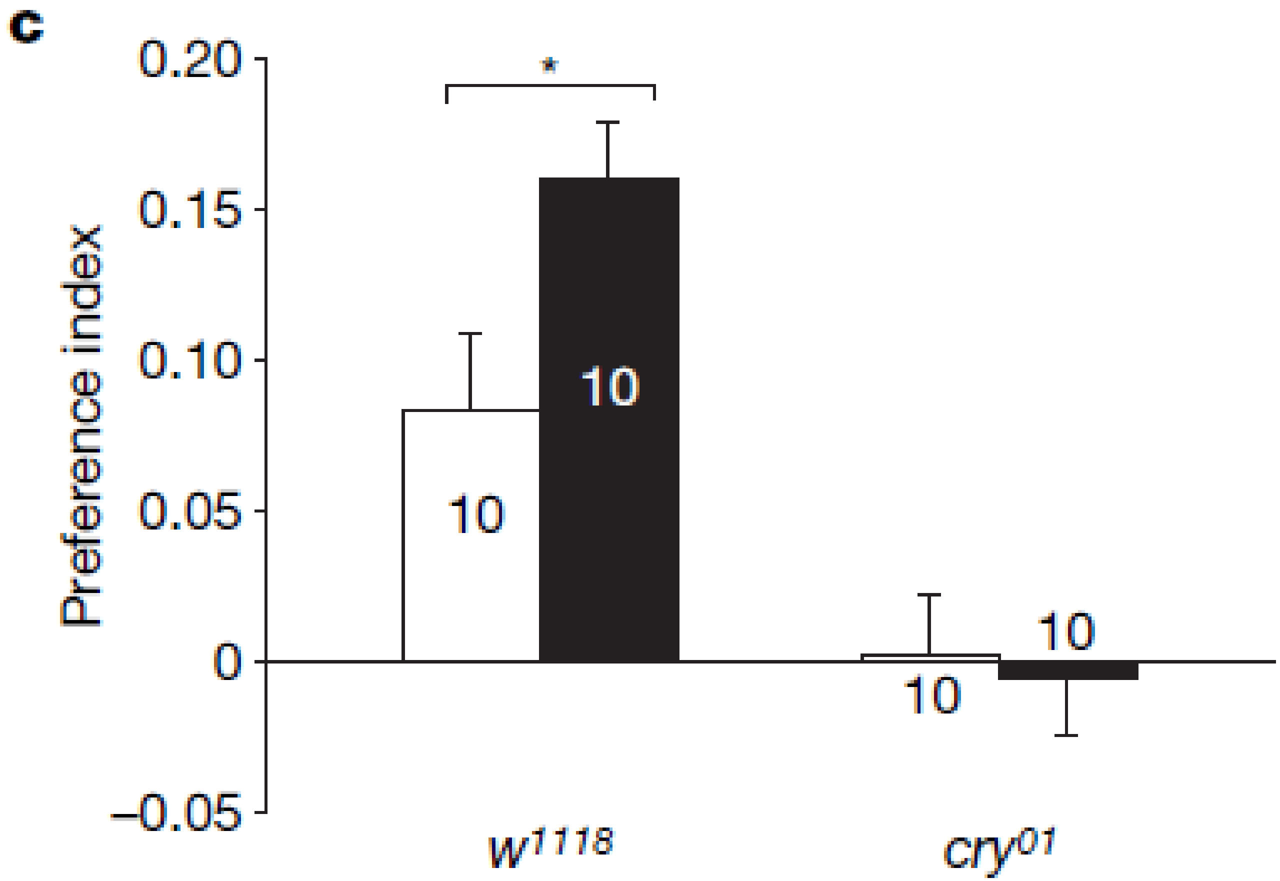






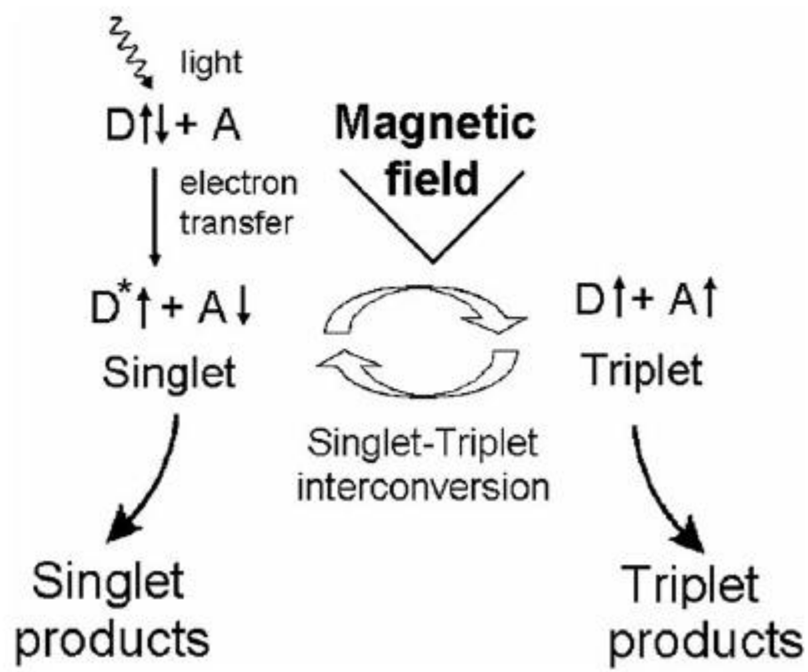


Magneto sensor system I - cryptochromes



Magneto sensor systems

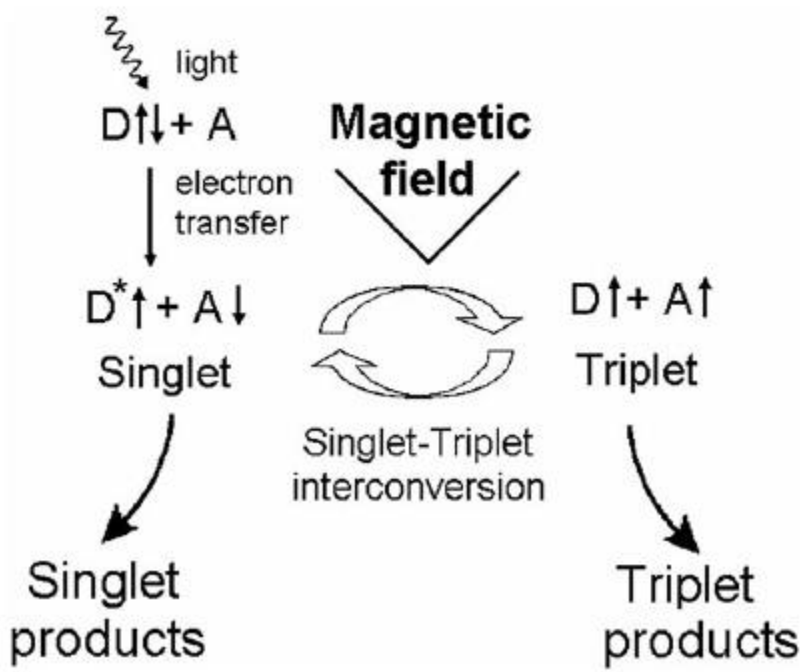
I



Main molecules - cryptochromes,
In birds localized in retina

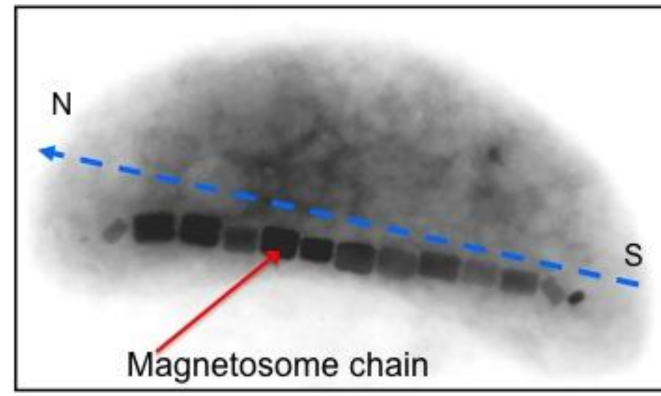
Magneto sensor systems

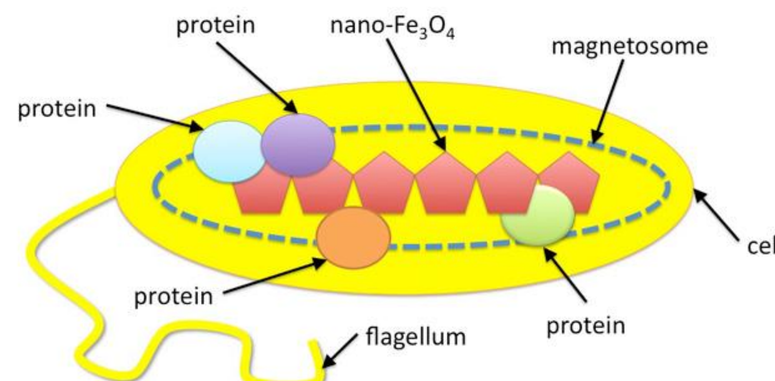
I



Main molecules - cryptochromes,
In birds localized in retina

II



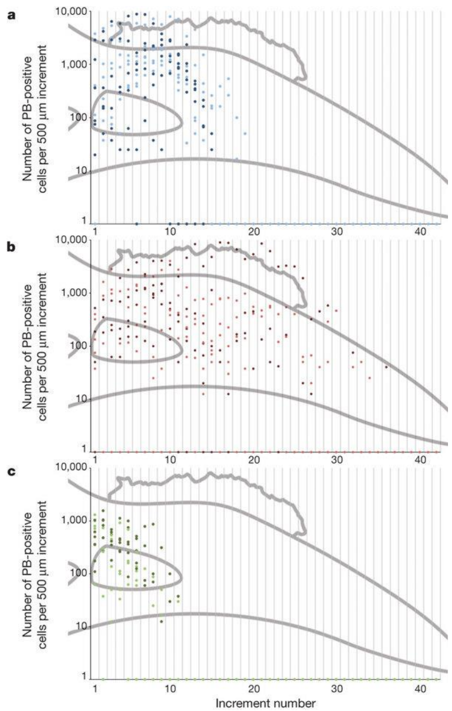


Main molecule – Fe_3O_4 ("magnetite")
In bacteria localized in magnetosomes

Magneto sensor system II

Localization of Fe_3O_4 in birds

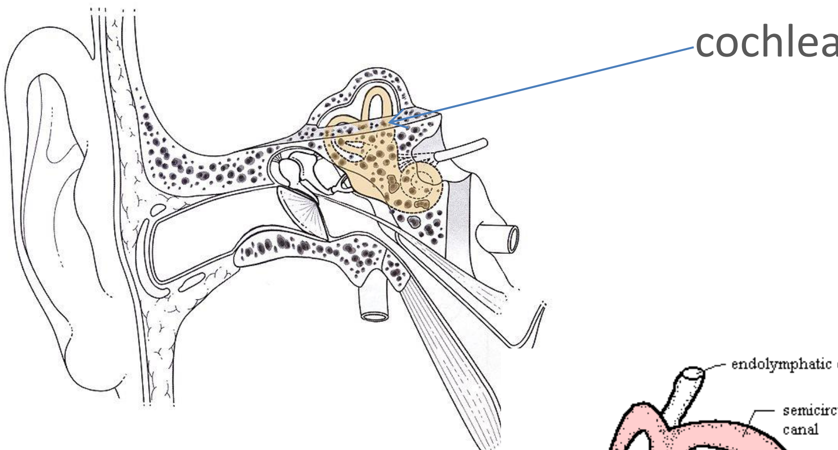
1. Upper beak



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

Christoph Daniel Treiber, Marion Claudia Salzer, Johannes Riegler, Nathaniel Edelman, Cristina Sugar, Martin Breuss, Paul Pichler, Herve Cadiou, Martin Saunders, Mark Lythgoe, Jeremy Shaw & David Anthony Keays

2. Inner Ear Lagena



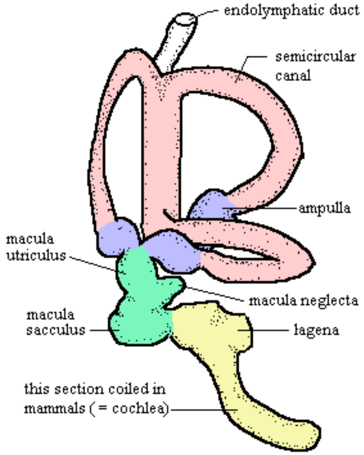
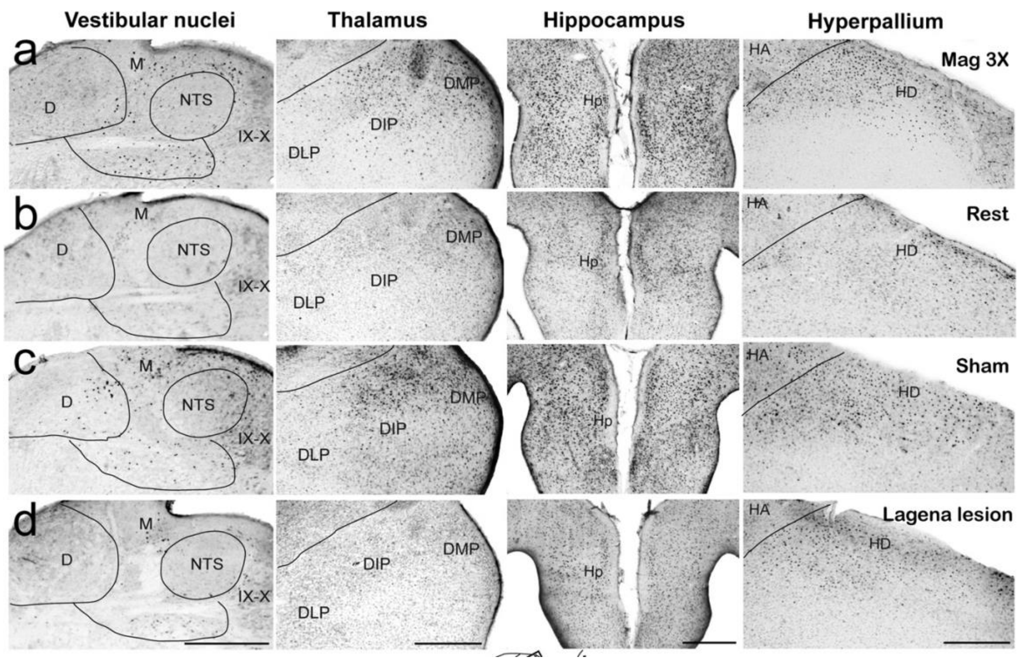
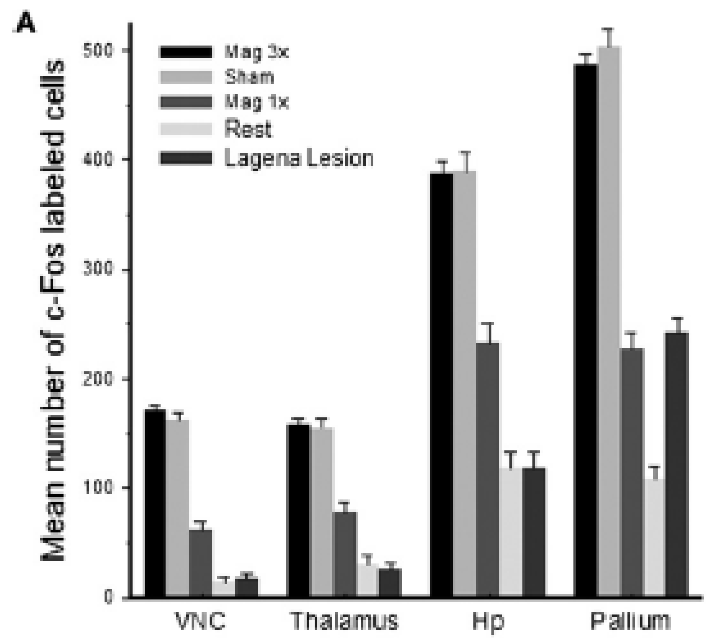


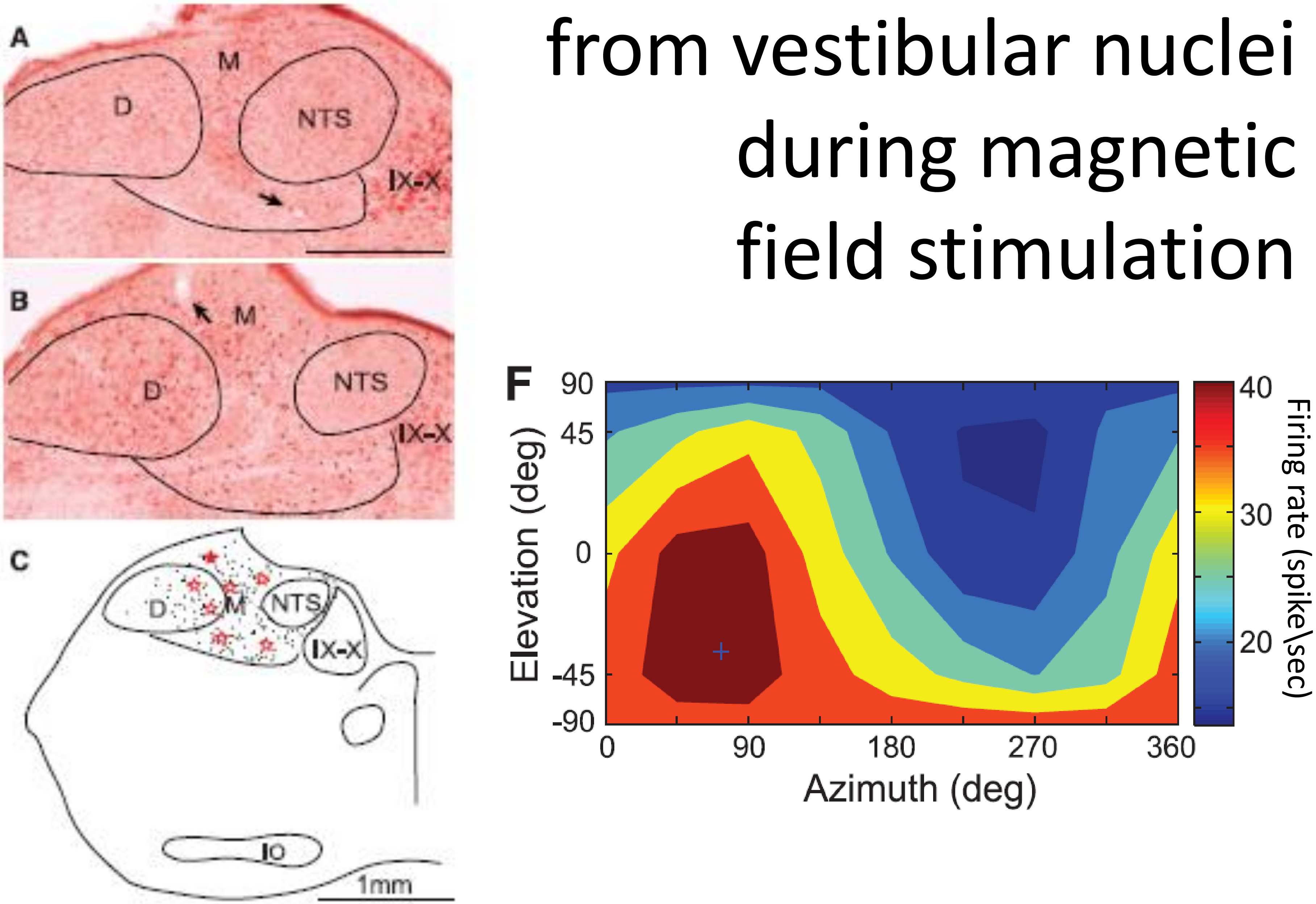
Fig. 3. Vestibular apparatus of inner ear. Neuromast structures are found in the ampullary organs (blue), macular regions (green), and lagena (yellow).

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?

P.S. – Растительный магнетизм?

Trends in Plant Science

Cell Press

Volume 19, Issue 1, January 2014, Pages 1–4

Forum

Magnetoreception: an unavoidable step for plant evolution?

Andrea Occhipinti[1], Angelo De Santis[2], Massimo E. Maffei[1,]