Neural Mechanisms 3

- ancestral species/evol. history
- species' evol. history
- individual's lifetime
- now

phylogeny

function

development

cause

ultimate

proximate
Outline

• Cortical magnification
• Geomagnetic migration

(a) star-nosed mole
(b) eastern mole
(c) masked shrew
(d) hedgehog

http://www.youtube.com/watch?v=6m0PMcXK6XA
- Lives in wet soil
- Burrows in search of worms
- Worms cannot be seen
- Ignores visual information
- Relies on tactile information
- Appendages 11 are heavily used

Mouth

nostril
Cortical sensory map of the star-nosed mole

- Anesthetized moles
- Recorded action potentials in cortical neurons
- Touched different parts of nose
- Created a “map”
- Appendages 11 get disproportionate representation
Cortical sensory map of the star-nosed mole

Allocation of brain tissue is not equal

![Graph showing average area of cortex per input fiber (µm²) for different appendage numbers](image)
Sensory analysis in four insectivores

(a) star-nosed mole
(b) eastern mole
(c) masked shrew
(d) hedgehog

- Allocation of brain tissue is not equal

- Is there a tradeoff?
Outline

• Cortical magnification
• Geomagnetic migration
• The Earth’s magnetic field varies across the planet’s surface and is therefore a potential source of positional information.

• Magnetic compass sense was first discovered in migratory birds.

• Adult turtles also use it.

• Neural mechanisms?
Neural mechanisms of geomagnetic migration

• Marine mollusc (sea slug) *Tritonia diomedea*

• *Tritonia* can orient magnetically.
Tritonia behavior

Fig. 1. Orientation of *Tritonia diomedea* under two ambient magnetic field conditions. (A) Orientation in the geomagnetic field. The group is significantly oriented \([n = 18, r = 0.58, \text{mean angle} = 87.6^\circ, P < 0.01, \text{Rayleigh test (10)}]\). (B) Orientation in a field with a canceled horizontal component. The distribution is indistinguishable from random \([n = 17, r = 0.19, \text{mean angle} = 29.0^\circ, P >> 0.10, \text{Rayleigh test (10)}]\).

Lohmann & Willows, 1987
Tritonia nervous system

- Large, individually identifiable brain cells and a simple nervous system
- Amenable to cellular-level electrophysiological analyses.

- Intracellular recordings: 3 pairs of neurons respond to changes in magnetic field (Pd5, Pd6, Pd7)
- First individually identifiable cells known to respond to magnetic fields in any animal.
Fig. 2. The electrical responses of LPd6 to an earth-strength magnetic stimulus. (A) The electrical activity of two different LPd6 neurons during initial experiments. The white bar beneath each trace indicates the 20 min baseline period. The gray bars beneath each trace indicate the 26 min period in which the magnetic field was rotated 60° every minute (see text for details). The first gray bar represents the first 6 min while the subsequent gray bar represents the last 20 min of the magnetic stimulus (the period when data was collected). Action potentials are between 90 and 100 mV in amplitude. (B) Summary of results from initial magnetic experiments (see text). The numbers of action potentials during the baseline period and during the last 20 min of the stimulus period are plotted. Values are means ± s.e.m. (N=11).
Fig. 9. Morphology and anatomy of Pd6 neurons. (A) Cobalt fill of LPd6 showing the large soma and primary neurite within the left pedal ganglion. Branches from the LPd6 primary neurite enter left pedal nerve 1 (LPdN1) and left pedal nerve 2 (LPdN2). Scale bar, 300 μm. (B) Cobalt fill of RPD6 showing branches from the primary neurite entering right pedal nerve 1 (RPdN1) and right pedal nerve 2 (RPdN2). Scale bar, 350 μm. (C) A schematic diagram of the innervation pattern LPdN1 and LPdN2 showing that these two nerves innervate the anterior regions of the foot. LPdN1 innervates the most anterior region of the foot, while LPdN2 innervates a more posterior region. There was little or no overlap between the areas of the foot innervated by the two nerves.
TPep influences cilia.
• The Pd6 neurons might function in any part of the magnetic orientation circuitry: (i) sensory neurons; (ii) integrative or processing role (interneurons); (iii) motor neurons

• The electrophysiological and anatomical evidence strongly suggest a motor role for the Pd6 neurons.