Magnetic Fields and Behavior

- **Earth’s field**
  - Causes biases in orientation (functional significance unclear)
  - Can be used as compass reference
  - Can indicate animal’s location on earth’s surface (magnetic map)

Example:
- Magnetic orientation in naked mole rats
- Learn tunnel direction relative to magnetic north (mN)

- **Local fields**
Feb 14: Magnetoreception

**Features of Earth’s Field Providing Information**

- **Intensity**
  - Earth’s field: 0.00003-.00006 Tesla (30,000-60,000 nT)
  - MRI magnet: 1.5-4 T

- **Polarity**

- **Inclination, or dip**

- **Declination** (difference between directions of true north and north magnetic pole)
Models of Magnetoreception: Mechanical Reception

- Uses the same principle that applies to a compass needle (magnetic field exerts a torque on a ferromagnetic material)
- Biological inspiration:
  - Existence of biogenic magnetite crystals in bodies of many organisms
  - Magnetic bacteria
    - Task: swim down into anoxic zone
    - Follow inclined field lines
- Could such magnetite clusters be basis of actual magnetoreceptors in animals?
Feb 14: Magnetoreception--magnetite con’d

Models of Magnetoreception: Mechanical Reception (cont’d)

- How to test magnetite hypothesis?
- Predicts that magnetic sensitivity should be wiped out by pulse of strong magnetic field

Example:
magnetic compass in monarch butterflies Etheredge et al. 1999

Orientation after magnetic pulse
Orientation after capture and release
Orientation of migrating butterflies

Retracted March 28, 2000
PNAS 97: 3782d-3782d
Etheredge et al.

Other examples: honey bees, migratory birds
Models of Magnetoreception: Electrical Induction

- Electric Induction: Movement in a magnetic field will result in an induced electric field.
- Elasmobranch fish (sharks and rays) have a special sensory organ to perceive electric fields with high accuracy and can use this organ also to detect magnetic fields.

However:
- Such an organ will only work in salt water (not in air), because there needs to be a path for the flow of electrons.

Location of Ampullae of Lorenzini (electroreceptive organs)
Models of Magnetoreception: Chemical Reception (mediated by photoreceptors)

- Capture of photon by photopigment involves transitions in energy state of electrons, leading to change in conformation of molecule
- The efficiency of this process, hence of photon capture, depends on alignment of photopigment molecule relative to magnetic field
- Over an array of photoreceptors (e.g., in retina), this may produce patterns of stimulation that depend on orientation of retina (or of

- One thing this model predicts is that magnetic sensitivity may be influenced by wavelength of light that animal sees
- Such wavelength dependence has been observed in newts and birds

- View that bird might have of visual field when facing in each of 8 compass directions
- Stripes are result of interaction of magnetic field with photoreception