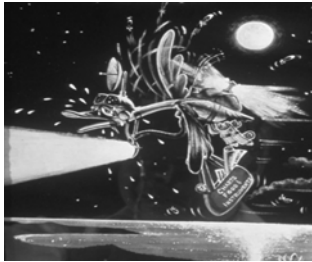


## Navigation and orientation

- Two major phenomena
  - Latitudinal migration
  - Homing behavior



## Homing behavior

- Displacement experiments have shown the remarkable homing ability of birds

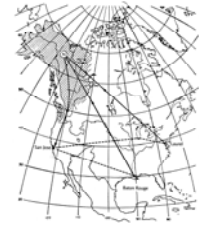


Table 14-1 Abilities of Birds to Return to the Site of Capture after Transport to a Distant, Unfamiliar Release Site

Species	Number of Birds	Distance (km)	Return (%)	Speed (km/day)
Leach's Storm Petrel	61	220-870	67	56
Maine Shearwater	42	491-768	90	370
Laysan Albatross	11	3083-7630	82	370
Northern Gannet	18	398	63	185
Herring Gull	109	396-1615	90	112
Common Tern	44	422-748	43	231
Barn Swallow	21	444-574	52	278
European Starling	68	370-815	46	46

(From Griffin 1974)

## Navigation requires.....?

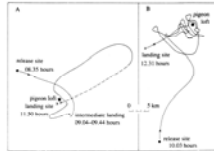


## Navigation requires a map and a compass

- Map and compass information are derived from:
  - Topographic features and other visual landmarks
  - The position of the stars
  - The angle of the sun in the sky
  - Olfactory information
  - Geomagnetic information
  - Polarized light

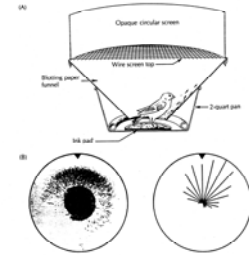
## Topographic features

- Evidence of use is ambiguous
  - Birds concentrate along flyways that follow mountains and rivers
  - Radar shows many nocturnal migrants do not use topographic features
  - Homing in visually impaired pigeons

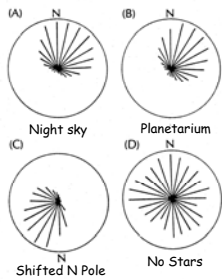


## Celestial navigation

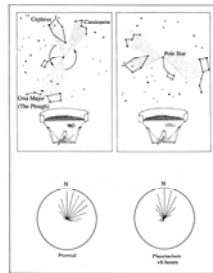
- Emlen funnels measured zugunruhe in response to celestial clues in a planetarium



- Experimental evidence that birds orient to stars in the night sky

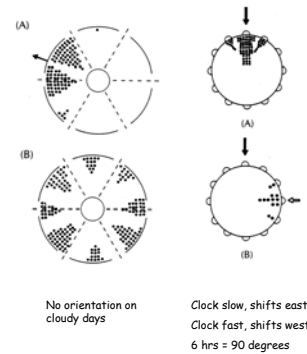


- Most species show no evidence that an internal clock is used in celestial navigation



## Sun-compass navigation

- Zugunruhe of Starlings in Emlen funnels shows that birds use sun position for orientation
- Clock shift experiments show that some birds use a precise internal clock in combination with the angle of the sun



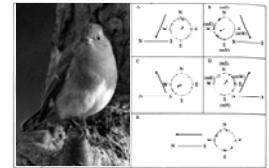
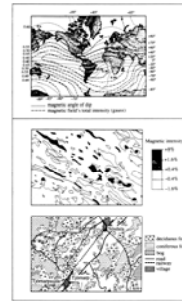
## Olfactory navigation

- Well developed in Procellariiformes
  - Dimethyl sulfide, a gas given off by phytoplankton may be clue
- Pigeons show reduced homing when smell is blocked
- Starlings use smell to find nesting material that inhibits parasites

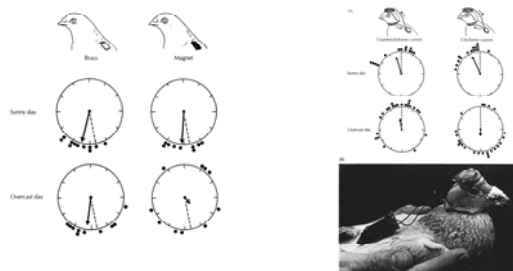


## Geomagnetic orientation

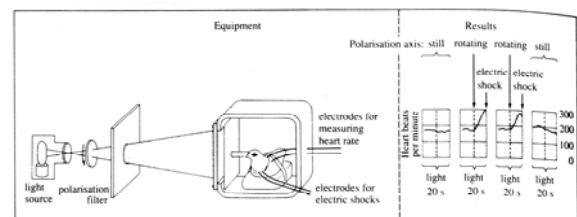
Birds shift their orientation in response to changing magnetic fields



## Magnets disrupt geomagnetic orientation

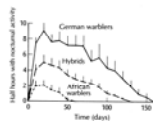


## Polarized light may be used for orientation



## Genetic components of navigation

- Peter Berthold (1988) created hybrids of migratory German Blackcap Warblers and non-migratory African Blackcaps
  - Zugunruhe of hybrids was intermediate
  - Migration patterns also intermediate



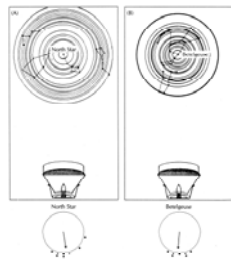
## Learned components of navigation

- Perdeck (1967) showed that adult birds can reorient using prior experience
- Juvenile birds practice simple directional orientation



## Baby Indigo Buntings learn the night sky

- If young birds not exposed to stars during first month of life they do not show celestial orientation
- Young birds can be trained to orient on novel star maps



## Summary

- Orientation and navigation uses genetic and learned components
- A map, compass and internal clock are used
- Multiple cues:
  - Sun
  - Stars
  - Magnetic fields
  - Odors
  - Landmarks
  - Polarized light
- Systems are redundant
  - Use varies with age and with conditions

