Homing and Migration

Homing

- Animals "home" when they return to a central place, such as their nest or their territory. Homing is a frequent activity, occuring after foraging bouts or other relatively local movements.

- This distinguishes homing from migration, which is a long distance movement between two distinct habitats.

- The key element to understanding homing behavior is determining which cues provide the directional information that allows animals to move between their home and other locations.

- Homing is the return of an individual to its home site.
- Animals leave their homes to find food, mates etc, and return for shelter, feeding of young etc.
- Environmental cues such as light, chemicals, magnetism and visual landmarks are used to find the home base.

A. **Honeybees (*Apis mellifera*),** like many other animals, forage from a fixed location, the hive. This type of foraging, often termed "central-place foraging" imposes a requirement for good navigation abilities; the animal must be able to find its way back home after a foraging bout which may take it away from visual or auditory contact with the nest and its residents. Honeybees may forage several kilometers from their hive, making them a good model species for studying navigation in central-place foragers.
   Information used in home-based navigation can be divided into two catetogories.

1. **Egocentric** information is generated internally by the animal and is independent of its immediate surroundings. Internal calculations of the distance and direction travelled, which are used in path integration, are examples of egocentric information.

2. Geocentric information includes landmarks and any map information available to the animal.

Honeybees primarily use path integration in making their way to and from foraging sites. Dance information provides outgoing bees with a distance and direction to be travelled.

Flight direction is determined by a sun compass orientation, and distance of flight by an internal "odometer" that measures the rate at which visual images flow past the eyes.

Other inputs, such as odors, provide supplementary information. Once a route is learned, bees incorporate visual landmarks when they make repeat trips to a foraging site.

The return trip is governed by path integration as well, but also may be informed by landmarks.

How do bees incorporate landmarks into their orientation?

Two basic models, snapshot memory and cognitive maps, have been proposed. The simplest, and probably correct, model calls for the bee to remember a series of visual images ("snapshots") of the landscape as it passes.

- The bee also remembers images of particularly prominent landscape features. These images can then be compared with the actual landscape surrounding the bee at any given moment.

- More complex is the "cognitive map" model, which requires the bee to construct a relatively complete neural representation of the landscape based on its experiences while flying. Tests of the cognitive map model require that displaced bees calculate a novel route home, based on their memory of the landscape map (as humans might).

B. Homing behavior in pigeons, *Columba livia*, is interesting because pigeons find their way home from unfamiliar sites up to thousands of kilometers from their roost.

Pigeon races may feature releases of birds from France, for example, which then find their way home to sites in England or the Netherlands. The extraordinary reliability of homing pigeons makes them excellent subjects for studies of navigation.

How do pigeons find their way home when deposited in an unfamiliar location? To do this, they must have two kinds of information.

I. The first, called **"map sense"** is their geographic location.

II. The second, **"compass sense"** is the bearing they need to fly from their new location in order to reach their home.

If either information source is disrupted, then homing fails or is delayed.

1. The map sense

In familiar surroundings--locations from which pigeons have previously homed or landscapes through which they have flown--landmarks play a predominant role in homing. Pigeons learn visual features of the landscape and use these visual features to determine their current position (map location) relative to their roost. While pigeons clearly use visual landmarks, because pigeons orient better in familiar landscapes when other sensory inputs, such as olfaction, are eliminated, direct tests of landmark usage are diffiicult.

How do pigeons produce a map sense when they are released in a completely unfamiliar location?

The answer is that they use olfactory cues. In their roost, they associate odors with wind directions. When released, they assess the odor of their new location and extrapolate the map location from their roost-gained knowledge of winds and odors.

Pigeons in visually unfamiliar territory whose sense of smell has been disrupted (by cutting olfactory nerves or treatment of the nasal passages with zinc sulfate solution) have a great deal of difficulty homing.

Similarly, if the roost is blocked from winds and provided with filtered air, homing fails. Pigeons may home better if they have some time to olfactorily experience their new surroundings prior to release.

The compass sense

The primary compass information of pigeons comes from the position of the sun in the sky. By integrating their internal clock with the sun's position, they compensate for the apparent movement of the sun across the sky.

Pigeons whose time sense is shifted by keeping then under artificial lights display incorrect orientations when released. For example, if "sunrise" comes for the pigeons 6 hours prior to actual sunrise, then their orientation is shifted counterclockwise. If their "sunrise" is later than the actualy sunrise, then their orientation shifts clockwise.

Like migrating birds, the pigeon's sun compass interacts with a magnetic compass. Under some conditions, experimental modification of the magnetic field around pigeons causes problems in homing.

Experiments with clock shifts and magnetic disruption often do not interfere as much as expected with homing. This is because the olfactory and landscape information used in establishing their map sense can be used to correct for compass misinformation.

Another possible source of landscape information is the pattern of ultrasonic reflections from mountains.

Migration

- Regular, annual or seasonal mass movements made by animals from their breeding area to another area.
- ‘True migration’ – the animal makes a return trip, back to the original breeding grounds.
- ‘One-way migration’ – often occurs when habitat deteriorates or food source is depleted.

Eastern bar-tailed godwits

- One exceptional long-distance migrant makes the journey from the Arctic without any stopovers. The eastern bar-tailed godwit makes a record-breaking non-stop flight over the Pacific Ocean from Alaska to New Zealand. This journey of **11,000 kilometres takes six to eight days and nights of continuous flight, averaging over 60 kilometres per hour.** The departure is timed to gain assistance from favourable winds. The birds arrive exhausted and weighing less than half their original weight. They remain for around five months before making the return journey along the western edge of the Pacific.

Why migrate?

- Enables the animal to live in a ideal environment with good food supply all year.

However, there are advantages and disadvantages.

Advantages

- Animals remain in a favourable temperature
- They grow larger
- Constant food supply
- May lead to the colonisation of a new area.
- Reduces predation and disease from parasites
- Greater genetic mixing
- Better breeding conditions

Disadvantages

- May get lost or caught in a storm
- May get eaten
- May use too much energy and become exhausted
- May starve
- Migration is a huge investment of energy.

Migrations can be triggered by internal or external factors

Internal factors:

- maturing of the sex organs (eg. In salmon there is a desire to breed).
- genetic drive (innate).

External factors:

Environmental cues

a) shortened day length

b) drop in temperature

Eg. Migratory birds sense a change in day length through skin and feathers which is registered by the pineal gland. They become restless, and fly for longer periods of time. This behaviour is innate as its also shown by caged birds.

Sea turtles have a migration pattern somewhat similar to that of salmon. Adult females migrate to their natal beach and lay eggs in the sand. Hatchlings undergo a short but high-risk, due to predators, journey to the shoreline, and then swim to the open ocean. Initially their swimming direction is oriented into the waves; near shore the waves provide an indication of the direction of the open ocean. Their migration then continues for hundreds or thousands of kilometers into the ocean, into favorable feeding grounds.

Turtles may actually use the geomagnetic field to tell them their location (of course, the open ocean has no landmarks); if this is the case, then their **magnetoperception s**ystem seems to work on a more refined level than that of birds, which is thought to provide directional but not locational information. Some scientists think that sea turtles probably use the geomagnetic field to orient their swim in the deep ocean, but they would also have **celestial cues** available to them

Salmon undergo a remarkable odyssey during their lives. Young salmon leave the freshwater streams in which they hatched, move thousands of kilometers into the open ocean, and then return as adults to spawn in their natal stream.

The question of how they find their way back after many months and an enormous travel distance has intriqued scientists for decades.

Starting with nearly adult fish, which initiate their journey to freshwater, the migration can be broken down into two phases.

- The first is locating the coastline or general area of the freshwater source they are seeking.
- The second is the specific identification of the stream from which they migrated earlier in life.
  While they can find the coastline without experiencing the outward swim, they cannot locate their natal stream without that experience. Thus it appears they learn some of the vector information on their outward migration. Salmon have magnetite and may be able to use geomagnetic information in orientation; such information might allow them to find a coastline.

Given that the salmon have do have a travel vector for long distance migration, they have several possible sources of compass information for orienting their travel.

These **include polarized light, the sun, and geomagnetic information. Ocean temperatures and currents may also provide information**.

Once the salmon are close to their natal stream, they identify the appropriate freshwater source by olfaction. Young salmon, perhaps primed by the hormone thyroxine, imprint on a stream-specific chemical signature. This imprinting may take place during the transition from the parr to the smelt stage in development.

Navigation: involves an animal finding its way over unknown territory to a known destination.

Methods used by animals to navigate (homing and migration)

1. Visual clues

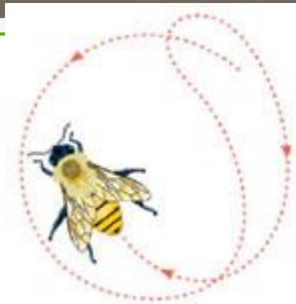
Animals can use visual landmarks, the shape of the coastlines, and topography of the land to navigate.

2. Solar navigation

Many birds and animals such as honeybees can use the sun as a compass. Because the sun's position is always changing due to the Earth's rotation, animals need to adjust for the changing direction of the sun. They appear to have an internal clock that does this.

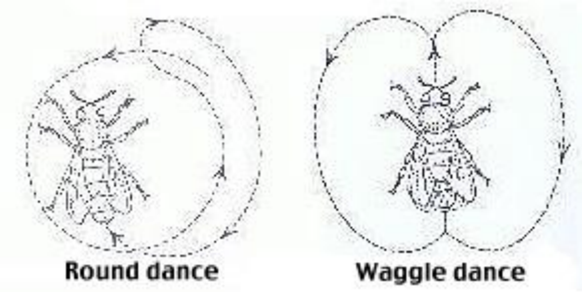
- Bees use the sun to communicate the direction and distance of a food source to other bees in the hive.
- Bees can do 2 types of dances – **a round dance** or a **waggle dance.**

Round dance



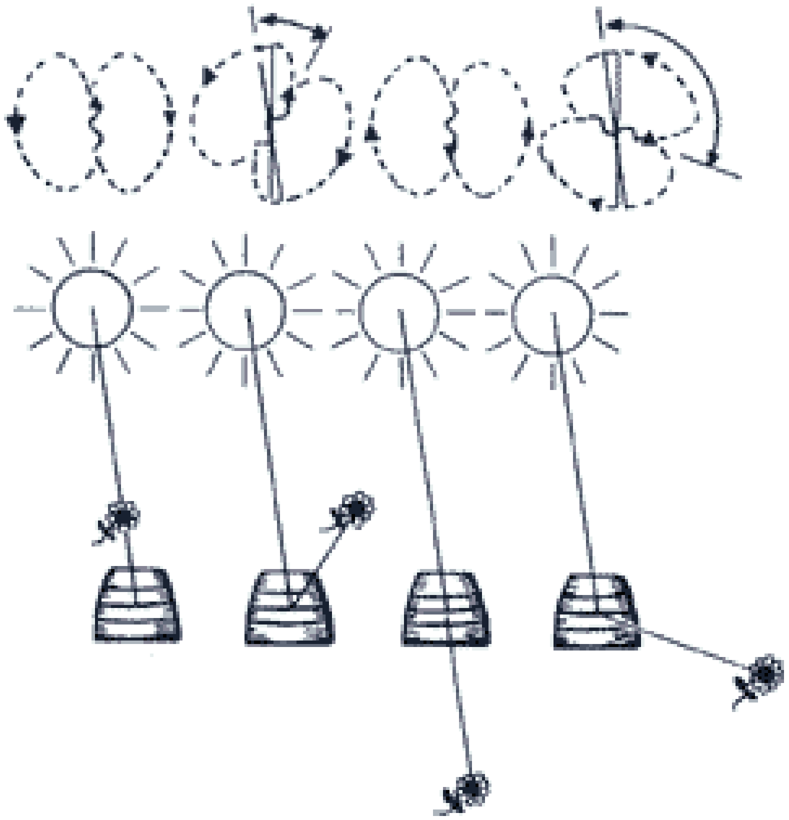
- This is performed by the “scout” bee when food is close to the hive, (i.e. within 50m). The “scout” bee enters the hive, drops some nectar from a honey sac and dances in a circle, first in a clockwise, then in an anti-clockwise direction.
- A round dance does not give any information about the direction of the food.

Waggle dance



- During the waggle dance the bee dances not in a circle, but in a figure-of-eight. The speed with which the bee dances around the figure-of-eight and the number of waggles it does on the straight run between the loops indicates the distance of the food from the hive.
- Fast waggles indicate food is close to the hive, slow waggles indicate food is further away.

The direction of the food is also shown. The angle between the waggling dance and the vertical honeycomb relates to the angle between the pathway to the food and the sun.



3. Magnetic fields

- The earth is surrounded by magnetic field lines which radiate between the North and South Poles.
- Some animals, eg. Homing pigeons, whales and dolphins have magnetic compasses in their heads which means they navigate using the magnetic field lines.

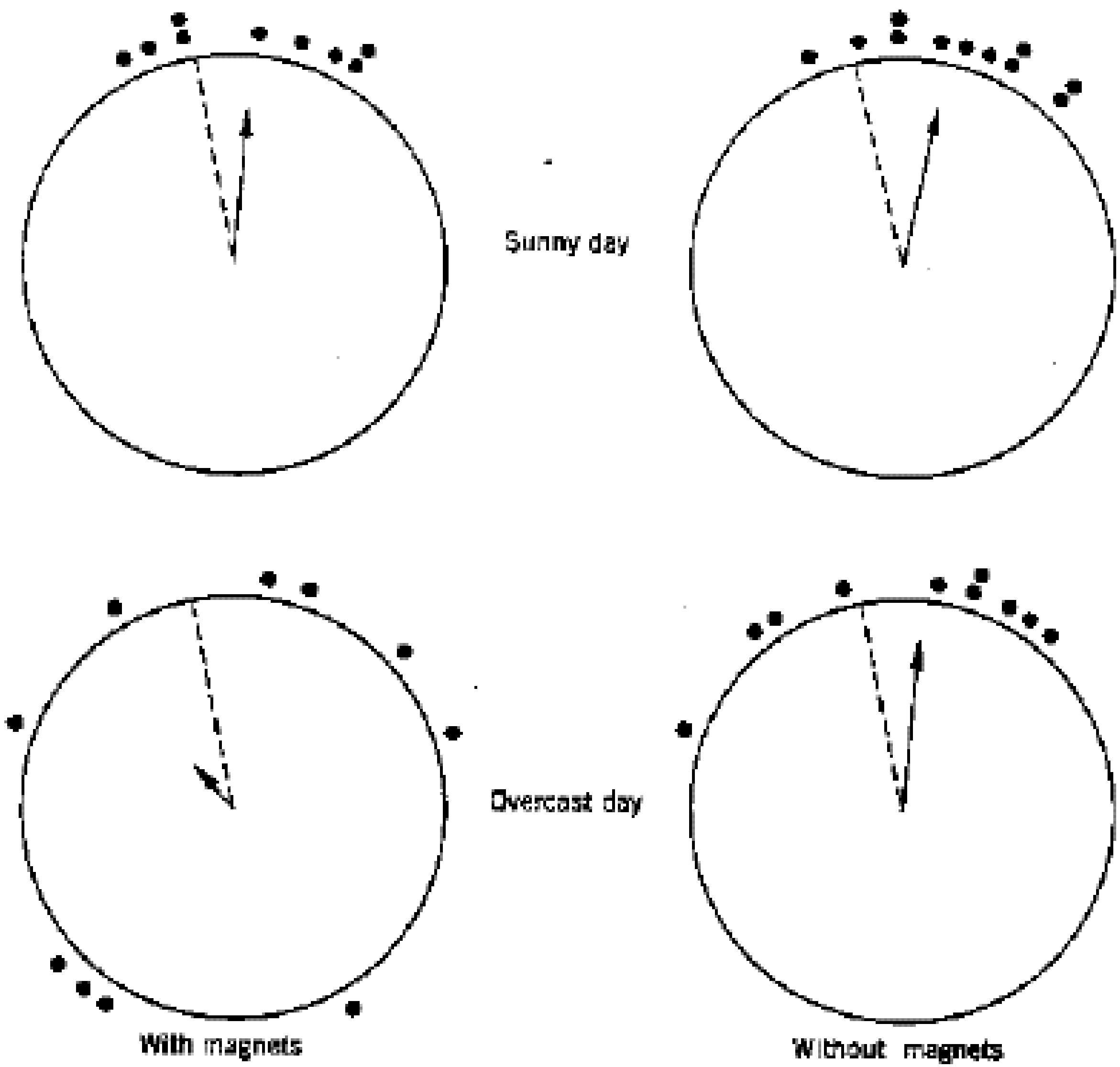


Figure 11.21 The influence of magnetism on pigeon homing. Pigeons were released with either a magnet or a brass bar of the same weight on their back. On sunny days, the pigeons used the sun as a compass and homed accurately with or without a magnet. However, on cloudy days, the magnets disoriented the birds. Each dot represents the birds vanishing direction. (Modified from Keeton, 1971.)

4. Navigation by the stars

- Birds that migrate at night use a star compass.
- Because the Earth rotates, birds orientate towards the part of the sky that appears to rotate the least. They orientate towards the brightest northern stars as these move the least during the night.

5. Chemical navigation

- Dogs follow scents to find home.
- Ants leave chemical trails for other animals to follow.
- Salmon return from the sea to their rivers using the smell of the rivers and surrounding environment.

6. Sonar sound navigation

- Bats navigate by using high-pitched squeaks which bounce off objects in their path.
- Humpback whales use sonar by making clicks and booms to navigate from the Antarctic and Artic oceans back to the equatorial waters for breeding.
- Sonar = sound navigation and ranging