The internal compass of the pigeon

SCIENTIFIC NAME
Columba livia domestica

TAXONOMY
PHYLUM: Chordata
CLASS: Aves
ORDER: Columbiformes
FAMILY: Columbidae

© 2013 Nature America, Inc. All rights reserved.

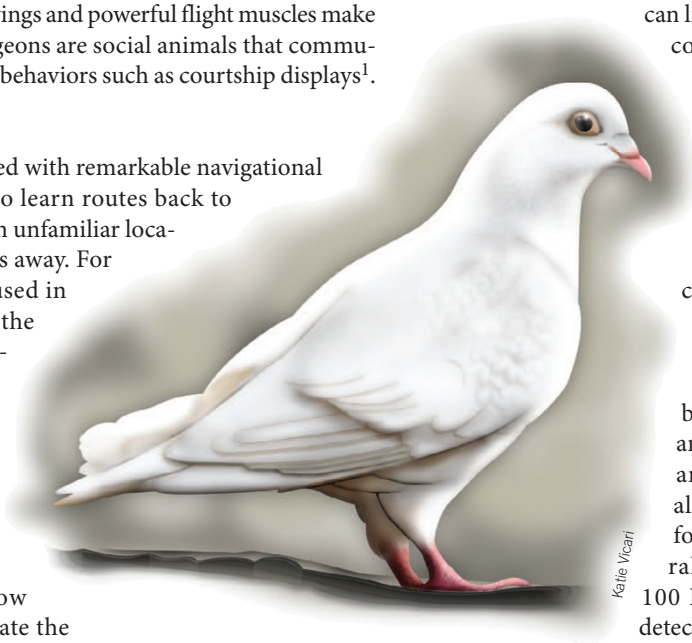
npg

Physical description

There are more than 200 distinct breeds of domestic pigeons, all descended from the rock dove (*Columba livia*). Pigeons are plump, small-billed birds with variable plumage. Their bills are slender and rounded and usually short, with a skin saddle between the bill and the forehead. They can have round or square tails and range from 12 to 33 in long. Their long wings and powerful flight muscles make them strong, swift fliers. Pigeons are social animals that communicate by exhibiting distinct behaviors such as courtship displays[1].

Homing behavior

The homing pigeon is a breed with remarkable navigational skills that allows the bird to learn routes back to home when released from an unfamiliar location even hundreds of miles away. For this reason, pigeons were used in ancient times by people of the Middle East to carry messages[2]. At the beginning of the nineteenth century, races between homing pigeons were organized in Belgium, leading to the selective breeding of the fastest homing pigeons[2].



Homing pigeons are now frequently used to investigate the mechanisms underlying their unique navigational abilities. A micro-global positioning system (GPS) can be attached to a pigeon's back to provide detailed analysis of homing tracks and flight trajectories, which can then be correlated with recorded neurophysiological data[2]. Using this approach, researchers have found that pigeons can form a memory-based 'navigation map', a spatial representation that allows a pigeon to determine the direction of, and possibly the distance to, home from even unfamiliar locations. Pigeons rely on several orientation mechanisms and cues—the sun, olfactory signals, visual landmarks and the earth's magnetic field—to polarize or discriminate among directions in space, like a compass[2].

How birds obtain magnetic field information has been a mystery. The prevailing model suggests that one structure in the eye delivers a magnetic reference direction and a second in the upper beak measures intensity of the field as input for the navigational map[3]. Contrary to this theory, Wu and Dickman[4] recorded electrical activity from >300 neurons in the pigeon brain stem and found that the brain stem receives a large number of simultaneous readings of different projections of the field vector from the inner ear, which the brain uses to obtain a precise representation of the field vector. If these inner ear sensors provide the necessary information, then the eye-beak theory seems unlikely.

Research résumé

Pigeons make convenient research models: they are inexpensive to keep and easy to manipulate, they reproduce readily and they can live up to 15–20 years under laboratory conditions[5]. The birds have been used in numerous comparative psychology experiments. Pigeons can share attention between different dimensions of a stimulus, can be taught relatively complex action–response sequences and can make discriminative responses to different categories of stimuli. In addition to their ability to discriminate, pigeons have remarkable vision and can thus be trained to discriminate, for example, between paintings by different artists[1] and between photographs with people and those without people[5]. Pigeons also have a superb temporal sensitivity for fast-changing images; their temporal resolution threshold reaches up to 100 Hz, whereas human observers can detect about 60 Hz (ref. 1).

1. Shimizu, T., Patton, T.B. & Husband, S.A. Avian visual behavior and the organization of the telencephalon. *Brain Behav. Evol.* **75**, 204–217 (2010).
2. Mehlhorn, J. & Rehkämper, G. Neurobiology of the homing pigeon—a review. *Naturwissenschaften* **96**, 1011–1025 (2009).
3. Winklhofer, M. Physiology. An avian magnetometer. *Science* **336**, 991–992 (2012).
4. Wu, L.Q. & Dickman, J.D. Magnetoreception in an avian brain in part mediated by inner ear lagena. *Curr. Biol.* **21**, 418–423 (2011).
5. Herrnstein, R.J. & Loveland, D.H. Complex visual concept in the pigeon. *Science* **146**, 549–551 (1964).