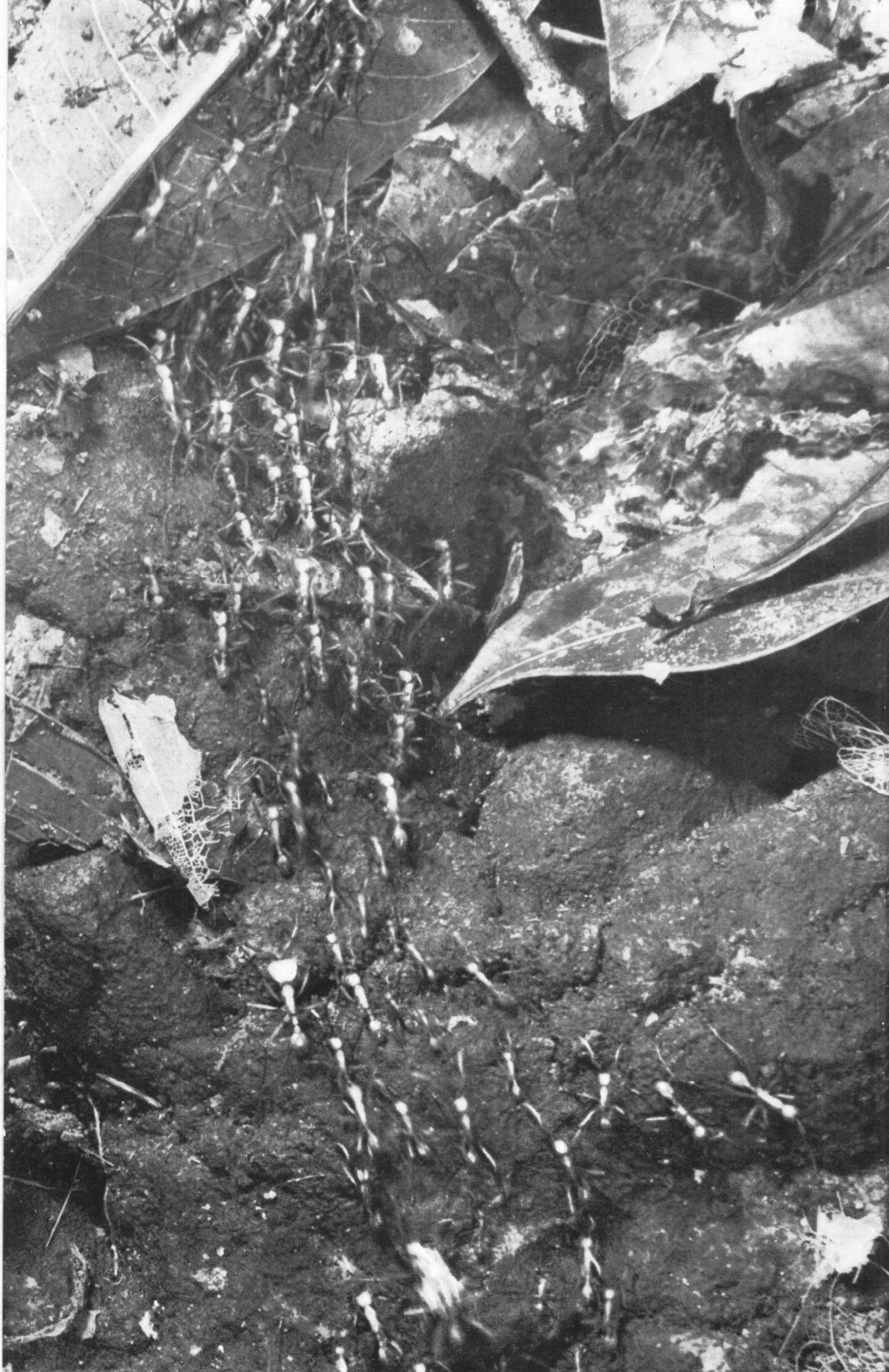
*Animal Navigation*



# *Animal Navigation*

HOW ANIMALS FIND THEIR WAY ABOUT

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To
MY WIFE
—for many reasons

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### SUGGESTED FURTHER READING

C. G. BUTLER — *The World of the Honeybee*

KARL VON FRISCH — *The Dancing Bees*

G. V. T. MATTHEWS — *Bird Navigation*

C. B. WILLIAMS — *Butterfly Migration*

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CHAPTER I

# *Animals and Men*

WHEN men first ventured upon the sea in boats, they crept anxiously along the coasts, for their craft were simple and unsuited to the open sea. But even when ship-building improved and boats became seaworthy their crews still kept to the shore. Mediterranean trade was confined to coastwise routes for many hundreds of years, for the open waters were treacherous, with sudden storms and violent squalls. But in time the northern sailors set out upon the open sea and the Vikings reached North America at an early date.

Thereafter the history of human navigation is one of increasing accuracy in calculating position and finding direction with the aid of instruments. Though it is true that some people seem to have a highly developed sense of direction—so called—most navigators depend upon instruments to measure the position of the sun, its height above the horizon and so forth, for navigation by the sun is the only possible way on the open ocean. But for sun navigation accurate timekeeping is essential and the invention of a reliable chronometer permitted a great advance in the accuracy of position finding. A compass, made at first of magnetite, or lodestone, will give the direction in which a ship is sailing but without a way of determining position one cannot be certain how far a ship has sailed.

But, of course, men had to find their way over long distances before they took to the sea. Early man was probably a nomad who moved on to new ground when he had exhausted the old. On the land there are landmarks—hills, trees, rivers, etc. The old tracks in the south of England, the ley ways, can still be traced by the clumps of trees which marked them in open country and by the V-shaped nicks in the hills to which they headed. But on the sea there are no such features, only the sun by day and the stars by night to steer by, and since the sun moves, to use it for navigation is more complicated than following a fixed chain of features across the countryside.

Men set out from their homes by land or sea only if they believe there is something desirable at the end of the journey: riches, new lands or simply the possibility of adventure. Yet animals too set out on their travels for much the same reasons as we do, but in animal terms riches are new supplies of food, and new lands, better places for laying eggs and bringing up young. Nevertheless animals are not adventurous! The parallel is really rather imperfect, for human travellers are activated by a conscious desire to reach their goal while most animals are not even conscious of their needs, much less of how to fulfil them. The stream of Brighton-bound cars on an August Bank Holiday is not really equivalent to the trek of sandhoppers seawards from the dry to the moist sand where they are more likely to survive.

Animals need certain things from their environment apart from food. There are optimum conditions of temperature and humidity for example, and even of the mechanical structure of their surroundings. The hot, dry and hard surfaces of rocks, to take an extreme example, are inhospitable to animals, who cannot even burrow into them for shelter, as they can in the shifting sands of a desert. Though animals appear to choose their habitats, vacating others to move to them, in reality it is innate behaviour, not conscious choice, that impels them. Those which prefer moisture may be restless on dry surfaces, but become quiescent in wet places. Others shun the light which drives them into the cool, moist, dark places they prefer.

The world of an animal is, then, a patchwork of places where the living conditions are bad, not so bad and good. For various reasons the pattern changes frequently; moist soils dry up, leaves die and no longer give shelter from the sun, and a hundred and one accidents of nature, as well as the changes of the seasons, will influence it, and the animals must move away. Sometimes the distance they must travel is measured in millimetres, sometimes in hundreds of miles. A protozoan need swim only a tiny distance to avoid a local concentration of carbon dioxide in the water, while birds migrate across continents to favourable breeding places, but even the protozoan's journey, short as it is by our measure, is long for a creature of its small size.

How to get to the new place presents a problem. The bigger animals like birds and even some insects actually seem to aim for a definite point. The annual visits of swifts and swallows to the same localities, and often to the same nests, are witness to the accuracy with which birds navigate. And the bees, laden with honey or pollen, that cluster round the hive entrance, have returned from flowers hundreds of yards away; they use methods of navigation which are like some we ourselves use—though no animal carries a compass or uses anything comparable with the electronic devices upon which modern travel is becoming increasingly dependent.

The sun is the main beacon, not surprisingly as it is absolutely certain to be in the sky by day. But animals may be able to perceive aspects of the sun's presence which we cannot. Though some animals are sensitive, few people can see in the sky the pattern of polarized light which is intimately connected with the source of light which forms it, the sun itself. But, bee or bird, they also learn to recognize landmarks, selecting them to mark the route or to pinpoint places where they must alter course, just as the ancient navigators watched the shape of the shoreline for familiar towers and hills. By this means an area becomes familiar and the animal can return to its nest or its colony from anywhere within it. More remarkable still is the ability to return home from unfamiliar places where the landmarks are unknown, which demands from birds and some mammals an ability to judge their position in relation to their home—whether (to use human terms) they are to the east or west, north or south of it, thereby determining the direction in which they must move.

The insect's world is a world of scent, as well as colour, light and shape. We have only a poor idea of the splendour of this olfactory universe, like colour-blind men gazing at a painting full of subtle nuances of colour. But a track can be marked by the scents which linger round it as well as by the trees and grasses which surround it. To this we are insensitive, but dogs and insects are acutely perceptive of odours and tastes.

Navigation seems to imply guidance to a goal, though the more intrepid explorers were those who sailed into the unknown, ignorant of, or perhaps preferring not to know, what awaited them. They are none the less granted the name of Navigators. Many animals, particularly the smaller invertebrates, make their ways about in an erratic search for suitable dwelling places. They do not know, in the human sense, what their goal is, nor where they are liable to find those near-ideal conditions which they seek. They wander on, encountering the right places by chance, but the probability of their finding the most favourable is increased by their inborn reactions to certain kinds of stimuli. When they encounter weak stimuli of the right sort they seek the source, which will be an area of stronger favourable stimulation. Thus an animal searching for food will creep up the gradient of chemical concentration from the weak outer fringes to the stronger centre where the food will be.

Some of the goal-less animals twist and turn in their search, but others go long distances along straight paths. It seems probable that this is the more efficient way of searching, though, since we know little, if anything, about the detailed distribution of favoured places for one of these small animals it would be hard to prove. However that may be, these animals—and most of the ones we know about are insects—do keep on their straight course by navigation. We know they do this because if we change their surroundings they react in the way we would expect. Thus, if we shade the sun from an ant and arrange a mirror so that the sun's rays now come from the opposite side, the ant turns round and runs in the opposite direction. Or again, the caterpillars of the pine sawfly crawl along in a straight line but turning a polarized light filter held over them may cause them to alter direction by turning through the same angle. In both cases the insects were navigating and were dependent upon these two stimuli for their direction.

We shall see that in both long- and short-distance navigation the same sorts of beacons are used, but the ways in which animals use them may not be ours.

## CHAPTER II

# *Scent Trails*

THE fog comes down into our city streets and we fumble our way home. Our familiar landmarks are gone and we must depend upon groping hands and a timidly extended foot. But even in our partial blindness one sort of landmark suddenly obtrudes itself into our thoughts, as the smell of the fish-and-chip shop on the corner grows stronger, until we know for certain where we are. Man's sense of smell is not well developed; it is, in fact, so poor that when we watch a dog snuffling along a street or a country lane we cannot imagine the rich world of smell in which he lives. Many other animals besides dogs use their sense of smell, for man and birds are the exception to the general rule of well-developed sensitivity to chemical substances. Many mammals mark their territory with scent. Food and mates are recognized and located by their scents in many creatures as will be shown by the extraordinary journeys made by male moths in search of females, which we shall discuss later (Chapter X).

A good example, and a familiar one to zoologists, is the way in which planarians find their food. Planarians are small, flat worms, with simple internal organization. Their mouth opens at the end of a proboscis normally concealed in a pocket half-way along the body. They are carnivorous and some live in streams. These worms crawl along the bottom moving in straight lines until they come near food, from which juices containing attractive chemicals are diffusing into the surrounding water. On the worm's head are organs sensitive to these chemicals, and, as soon as they are stimulated, the worm begins to make side-to-side movements with its head. It tests the water on either side of its path: as it turns towards the food it encounters greater chemical stimulation than when it turns away (fig. 1). So, always swerving to the side which is most stimulated, it moves in a long curve towards the

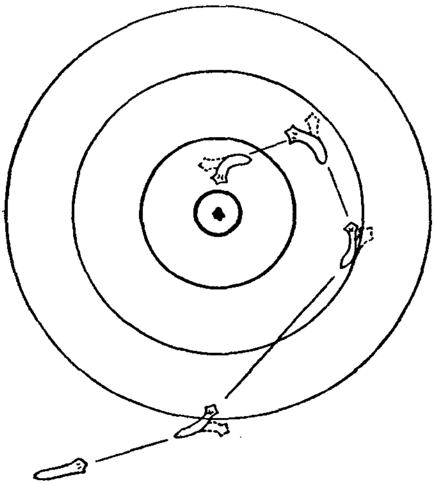

FIG. 1.—A planarian reaches food by testing the water and turning towards the greater chemical stimulation. The rings represent the diffusion outwards of food chemicals.

food until finally it is close enough to put out its proboscis and start feeding.

This is a perfectly simple but an extremely effective device. Though it is automatic, in that the worm does not 'think,' it is not completely invariable, for only a hungry worm is drawn to the food; after it is satiated, food chemicals lose their stimulating power—a useful economy in behaviour, which is found in many animals. When a particular physiological need is satisfied, then the behaviour that has resulted in that satisfaction is temporarily abolished, coming again into full play when the need arises.

This kind of behaviour—comparing the amount of chemical in two different places successively, as opposed to comparing them at the same time—is fairly common among invertebrate animals. Probably whelks, crawling on the sea floor (plate 1), find their