Audio-direction Finding in the Porpoise (*Phocaena phocaena*)

THE excellent anatomical work by Reysenbach de Haan[1], the important work on *Tursiops* by Scheville *et al.*[2], and numerous field observations have shown that cetaceans hear extremely well. *Tursiops* appears to possess a sonar system of remarkable quality[3] and one is inclined to believe that such a system may be of general occurrence[4], at any event among the toothed whales.

One of the striking features of hearing in the animal kingdom is the perception of the direction of sound. Experiments with man have shown that the accuracy of perception of direction is based on the difference in time the sound needs to reach both ears. In the case of pure tones and continuous tones the case is somewhat more complicated, phase differences playing a major part at lower frequencies up to about 2,000 c./s., whereas at higher frequencies differences of intensity are of special importance.

Sedee[5] has shown that in man the accuracy with which the direction of sound is determined depends, first, on the angle between this direction and the sagittal plane of the head, and, secondly, on the distance between the ears. Using an artificial head twice as large as normal, he found the threshold angle of direction to be about half its normal value.

Since sound waves travel faster in water than in air, and since the working distance between the bullæ in the porpoise is smaller than that in man, the question arises whether at lower frequencies—where differences of intensity do not play a predominant part—discrimination of direction in cetaceans may be less accurate than that in man, owing to the smaller time-differences involved. In order to get some insight into the matter, experiments were made with a porpoise.

A male porpoise was trained to come to the vicinity of the source of a sound signal by rewarding it with a fish. The underwater signal was produced by a Philips commercial tone-generator and emitted by two barium titanate transducers, one at a time. The transducers were placed at varying distances from each other and the signal was a pure tone, click-free and of short duration ($\pm \frac{3}{8}$ sec.). The signal was given when the animal was on a marked spot at about 18 m. from both transducers. The porpoise could only reach the vicinity of a transducer—which were separated from one another by a net—through a corridor about 12 m. long, and the animal had to choose the right opening at that distance. The enclosure in which the animal was kept had muddy slopes and eel grass on its bottom. It was therefore practically free from disturbing echoes.

It was found that the porpoise chose the right corridor if the mean angle between the transducers—one on the left side and one on the right side of the sagittal plane in front of the animal—was at least 16°. This was when a tone of 6,000 c./s. was used; at 3,500 c./s. the minimum angle is less narrow, at least 22°.

It appears from unpublished observations of Sedee, especially made on our behalf, that in man, when using the same kind of signal (but in the air), the angle in question is about 16° at 1,500 c./s. (giving the same wave-length as 6,000 c./s. in water) and about 24° at 750 c./s. The narrowest angle obtained at 1,500 c./s. was 8–10°, however, apparently half the width of that in the porpoise. As the distance between the bullæ tympani of a porpoise is about half the distance between the ears of man, it appears that, roughly speaking, a porpoise in water and a man in air have about the same degree of acuity of perception of the direction of sound when similar wave-lengths are compared.

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PLANT PHYSIOLOGY

Effect of Light on Maturing Broad Bean Seeds

WE have recently shown[1] that the typical development of the etiolated broad bean shoot in darkness is modified by exposing the intact soaked seed to light and that the sensitivity develops at the time when the embryo takes up water. It was suggested that the embryo of the maturing seed may also be sensitive in the same way and that varying conditions of light during maturation may affect the subsequent development of the seedling.

The following experiment was carried out to test whether a light effect on the maturing embryo could be detected in seedlings grown in darkness. Plants were raised in natural light conditions, and some of the pods were enclosed in light-tight bags at an early stage when they were approximately 1 in. long. When mature the seeds were removed from the pods and dried in complete darkness. Seeds from uncovered pods were simultaneously dried in the light for the same period. All seeds were then germinated and grown in darkness; internode-lengths were measured after 13 days.

The mean length of the first internode from seeds matured in darkness (30 seedlings) turned out to be approximately 16 per cent greater than that from the controls (35 seedlings). This difference is significant at the $P = 0\cdot05$ level. Clearly the sensitivity develops during the maturation of the seed, and the effect survives a short drying process. The effect of light thus bears some resemblance to the vernalization effect on the embryo of winter rye in that treatment is effective in the maturing embryo[2]. The mean length of the first internode from seeds matured in the light does not differ significantly from that of controls grown in the dark from four previous experiments with commercially grown seeds (Table 1). It, in fact, lies above all the means from individual experiments.

Although the experiment was not designed to test this, the results suggest that the effect of light sur-