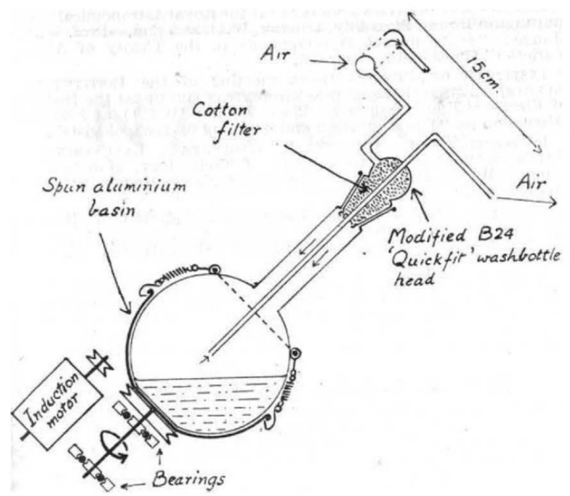

It has also been observed that, while the growth of *Staph. aureus* on a casein digest medium containing 'Marmite' and 1 per cent glucose in Roux bottles gives a crop in the stationary phase of rather less than 1 mgm. per ml. (16 hr. growth with a heavy inoculum, at 37° C.), growth in the rotated flask gives a crop of about 3 mgm. per ml. The rotated flask method has consequently been adapted for routine growth in place of Roux bottles, using 5-litre flasks, fitted with appropriate air exchange heads, containing 2 litres of medium. In one of these flasks, the same growth may be obtained as from thirty Roux bottles.

For operation outside the hot room, the device is housed in a small incubator through the sloping side of which the neck of the rotating flask is allowed to project.

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The Teleostean Swimbladder and Vertical Migration

It has been suggested by several authors[1–6] that the vertical movements of a teleost would be restricted by the presence of a swimbladder which will increase or decrease in volume when the fish moves up or down in the water. Fishes taken by line or trawl often arrive at the surface visibly distended, when they are said to be 'blown'. If they are taken from deep water the enlargement of the bladder may lead to the eversion of the stomach through the mouth or to the rupture of the bladder wall. This is well known to fishermen and has been an obstacle in fishery research, for example, in marking experiments on cod[7] and in the analysis of the stomach contents of hake taken from deep water[8]. But little appears to be known about the extent to which the swimbladder restricts vertical migration.

Since the problem is easier to study in freshwater than in marine teleosts, observations have been made on the perch (*Perca fluviatilis* Linn.) living in Windermere. In the late spring and early summer the fishes migrate into shallow water to spawn[9] and can be trapped in large numbers at depths ranging from 60 to 15 ft. Traps were set at different depths and hauled rapidly to the surface and the fishes opened up to see if the bladders were intact. The results are set out in the accompanying table, from which it will be seen that more than 80 per cent of the females taken from a depth of 45 ft. or more were found to have broken bladders. Only 14 per cent of those taken from 30 ft. had broken bladders, while all those taken from 15 ft. were found to have their bladders intact. The results for the males were slightly different, and a possible reason for this is given below.

Relation between the depth at which the perch were trapped and the percentage of the catch with broken bladders

Depth of the trap		60	45	30	15 ft.
Percentage of the catch with broken bladders	Males	97	93	61	1
	Females	93	80	14	0

At a depth of 45 ft., the perch are living under a pressure of $2\frac{1}{2}$ atmospheres, and the results show that when a perch is suddenly hauled to the surface from this depth the swimbladder will generally burst. If a perch is adapted to a depth of 45 ft., it will undergo a pressure reduction of three-fifths when hauled to the surface, and laboratory experiments have shown that in both sexes the bladder bursts when the total pressure to which the fish is adapted is reduced by this proportion. It would therefore be expected that the results of the trapping experiments would be the same for males and females. A possible explanation of the anomalies in the results is that some of the fishes in the traps had recently come from shallower or deeper water and in consequence were not adapted to the depth at which they were caught when hauled to the surface. But it is beyond the scope of this note to discuss this point any further.

The distance that a perch can migrate rapidly upwards before there is any danger of the bladder rupturing will, therefore, depend on the depth to which the fish is adapted. At a depth of 120 ft. the fish will be under a pressure of 4 atmospheres, and a pressure reduction of three-fifths will permit an upwards movement of 90 ft. before any danger is encountered. But the same proportional pressure reduction will only allow a fish adapted to 60 ft.—and thus under a pressure of 3 atmospheres—to swim up for 54 ft.

The bladder wall of the perch is thin and delicate, and it remains to be seen how far these conclusions apply to fishes such as the cod and the hake, which have thick-walled swimbladders.

Experiments have been made on the behaviour of the perch to changes of hydrostatic pressure, and on the speed with which it can adjust the gas content of the swimbladder when subjected to a reduction of pressure. From these and other experiments it should be possible to describe in a more precise way the limitations that the swimbladder imposes on vertical movements.

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