LETTERS TO THE EDITORS

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Immersion and Survival in Cold Water

A SURVEY of the results of experiments performed in baths[1] suggests that few men would live in water near freezing point for more than 30 min. and none for more than 1½ hr. Yet some people derive much pleasure and no harm from brief immersions in such water, and shipwrecked people are known to have survived after spending several hours in icy seas. Thus, Molnar[1] has quoted a group of twenty-three people who all survived long immersion in the sea although experiments performed in baths suggested that this should have lowered their rectal temperatures to 24° C., and he was surprised to find in another report that three men who had no life-jackets could hold up their heads after 1 hr. in water at 4–7° C. Critchley[2], moreover, has quoted an example of a man who survived after swimming for more than half a day in water at − 1·5° C. The following observations and calculations may explain this apparent contradiction.

All tests were performed on one subject aged thirty-six years, 180 cm. high, and weighing 85 kgm., who was a moderate swimmer and unaccustomed to cold water. The calculations apply to a man of his size. He first swam for about half a minute in an arctic sea inlet at a water temperature of 3° C. When he came out of the water his skin temperature was only slightly lower than it had been before, and it returned to near its original level within 10 min. although he was not artificially warmed. His rectal temperature rose by 0·4° C. immediately after the swim; this was probably caused by a mechanism which has been discussed elsewhere[3].

It can be calculated how fast this subject was losing heat in the cold water if it is assumed that his surface area[4] was 2·05 m.², the average conductivity of his superficial tissues between 9 and 10 Cal./m.²/hr./° C.[5–7] and the temperature of his deeper tissues near 37° C. (though it cannot be said exactly what the latter was[3]). At water temperatures of 0–5° C., this man should have lost some 12·5–10 Cal./min. Since his specific heat was probably 0·83[8], this rate of loss would have lowered his average body temperature by about 0·18–0·14° C./min. It is clear, therefore, that immersions of a few minutes in very cold water cannot cool the body to a dangerous extent.

Experiments have since been performed to study the heat production during swimming. They were done at water temperatures of 20° C. and air temperatures of 15–20° C. The subject swam with a Douglas bag on his back. Samples of expired air were analysed in Haldane's apparatus[9] and the heat production was calculated from the oxygen consumption. The results are given in the accompanying table. If the subject had been swimming in colder water his heat production would have been at a similar level, because it is evident from Spealman's data[10] that in the absence of shivering the heat production of a subject immersed in water does not depend on the water temperature. Even if the actual heat losses were a little higher than those calculated above[11], a man who is swimming hard should produce about as much heat as he loses in water near freezing point, and he should not die of cold as long as he is able to swim. Stiffness of the muscles may eventually interfere with efficient swimming; but muscles which are being exercised hard may remain warm enough to prevent them from becoming stiff. After rescue, moreover, a man who has been swimming would not require to warm his limbs at the expense of more important regions of his body[3], and he would continue to have a high level of heat production for some time. This may be a great help in resuscitation. Men in baths may shiver, but only after they have lost much heat, and they cannot produce enough heat by this means alone to balance their losses in very cold water[11].

HEAT PRODUCTION WHILE SWIMMING

Activity before collection	Activity during collection	Period of collection (min.)	Heat production Cal./min.	Heat production Cal./m.²/hr.
Squatting near pool	Slow swimming	1	8	234
Squatting near pool	Slow swimming	2	10·5	307
Slow swimming	'Treading water'	1	7·5	220
Moderately hard swimming	Moderately hard swimming	1	12·5	365
Slow swimming	Squatting near pool	2	4·5	134
Lying still	Lying still (basal metabolic rate)	12	1·2	34·1

Fit men, therefore, who are in danger of immersion in cold water, might be advised to swim or struggle as hard as they can for as long as they can. If they try to preserve their strength by clinging to wreckage or floating on their lifebelts, they will die from cold. Perhaps more lives would have been saved in the past if this had been understood.

My thanks are due to Prof. R. A. McCance for his interest and help, to the captain of H.M.S. *Truelove* (Cdr. A. S. Jackson, R.N.) for allowing the arctic experiment to be conducted from his ship, to the Master and Fellows of Emmanuel College, Cambridge, for the use of their swimming pool, and to Surg. Lieut. G. R. Hervey, R.N.V.R., for determining the metabolic rates.

E. M. GLASER

Medical Research Council
Department of Experimental Medicine,
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Comparison of Archæological and Radiocarbon Datings

SEEING that the radioactive carbon method for dating the past so lucidly described by Prof. F. E. Zeuner in *Nature* of November 4, p. 755, was evolved primarily to test certain physical hypotheses, it may be of interest to physicists to see how far the applica-