within the normal range of oxygen concentration in the environment. For sea water we may consider this normal range to be from 4.5 to 6.5 cc per liter at temperatures of 15° to 20° C.

A careful consideration of the data presented by Powers and Shipe in support of their contention fails to reveal any adequate indication of a direct relationship between O_2 tension and O_2 consumption in the restricted range we are considering. The fact that their experimental conditions were not standard may account for the fact that a number of their recorded values for oxygen consumption (cc per kilo per hour) are several times those previously reported for fishes. As for Hall's evidence, it is to be regretted that it is inadmissible on the grounds of faulty technique. Hall used a modified Ege and Krogh[3] apparatus in which the oxygen tension of the water was controlled by varying the rate of flow; in other words, the concentration of oxygen was diminished by the respiration of the fish and was then rebreathed in the large respiratory chamber used. It is obvious that the fish is excreting carbon dioxide at approximately the same rate that it is using oxygen and, even in a buffered system such as sea water, this will displace the hydrogen-hydroxyl-ion equilibrium and lower the pH. The marked effect of carbon dioxide on respiration is too well known to require comment. In addition, the accumulation of nitrogenous excretions in the water may possibly exert some effect.[4]

Hall mentions the work of Winterstein[5] in which it was concluded that the oxygen consumption of the fish (*Leuciscus*) is independent of the oxygen tension over a wide range. The important papers of Henze,[6] Gaarder[7] and Toryu[8] are apparently unknown to Hall and to Powers and Shipe. Henze concluded that the oxygen consumption of fishes is entirely independent of the oxygen of the water down to the threshold of asphyxia. Toryu drew similar conclusions from his experiments on the goldfish. Gaarder, using precise methods, found some indication of a direct relation between the oxygen tension in the water and the oxygen used by the fish, but concluded that, within a limited range, the oxygen consumption may be considered to be practically constant.

In my own experiments, water of really low oxygen tension was not used; the minimum concentration was 4.56 cc per liter. My methods were similar to those of Gaarder, but I did not narcotize the fishes as he did. Experiments on the same individual fishes (*Fundulus parvipinnis*), under identical conditions except for the oxygen tension of the water, did not give the slightest indication that the oxygen content of the water has any effect upon the respiration, but on the contrary the oxygen consumption was practically constant for any given fish. Experiments in which both the rate of flow and the oxygen concentration of the water were varied were likewise entirely negative, the respiration of the fish, based on the averages of a number of determinations, remaining remarkably constant, such deviations as were found having no relation to the available oxygen.

After considering all the available evidence it seems clear that the time has not yet come when we can make any very broad generalizations as to the relation of the oxygen tension of the environment to the oxygen consumed by the fish, but certain features are salient: (1) the respiration of fishes is very decidedly decreased at or near the asphyxial level of oxygen tension, and (2) in the respiration of the fishes so far investigated there seems to be practically a complete independence of deviations in the oxygen content of the water within a restricted range.

The practical importance of establishing this last point will be seen when it is pointed out that the methods which have previously been used for the estimation of the standard metabolism of fishes depend upon such an independence of the fish's respiration for their validity.

A more detailed discussion and presentation of evidence will shortly appear in the technical series of the bulletins of the Scripps Institution of Oceanography, University of California Press.

ANCEL B. KEYS
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