the following averages;

the composition of the 'Ersatzgas' determined
at the end of the third hour: carbon dioxide 5.5 %,
oxygen 87 %, nitrogen 7 %
at the end of the sixth hour: carbon dioxide 5.1 %,
oxygen 93 %, nitrogen 2 %

The composition of the 'Ersatzgas' at the end of the first hour was difficult to determine, since the volume of the swimbladder hardly increased, or on some occasions it even decreased to some extent at that time. But the averaged values for eight fish suggest that the actual increment of carbon dioxide in this interval is 0.02 cc, while that of oxygen is 0.03 cc. It should be pointed out that 1 part of carbon dioxide increased per 1.5 part of oxygen increment. Hence it may well be concluded that the 'Ersatzgas' is rich in carbon dioxide at the beginning of the secretion, but afterward the secretion of carbon dioxide decreases oxygen occupying the largest proportion.

The fuller description of the present note will appear in the Journ. Faculty of Science, Tokyo Imperial University.

Studies on the Physiology of the Swimbladder

II. The Mechanism of Gas Secretion

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The gas secreted by the red gland is apparently derived from the blood passing through the gland. Several investigators have shown that the activated gland receives more abundant supply of blood than the non-activated. Regarding the mechanism by which gas is transferred from the blood capillary to the swimbladder, it has been considerd that carbon dioxide is introduced first into the swimbladder at the activation of the red gland. This phenomenon may be explained most logically by assuming a secretion of certain acid from the red gland.

If acid is discharged in blood, carbon dioxide will be liberated from bicarbonate contained in blood. Then it will diffuse into the swimbladder. The diffusion will, however, be gradually retarded until it is stopped when the partial pressure of carbon dioxide becomes balanced on both sides of

the capillary wall of the blood vessel. If the amount of acid thus secreted becomes to exceed the buffer action of the blood, or if the diffusion of carbon dioxide into the bladder is prevented, an increase in the hydrogen ion concentration of the blood will be caused. Therefore the dissociation of oxyhemoglobin will be brought about according to BOHR's effect and it will result in an increase of oxygen partial pressure in the blood. Hence oxygen diffuses into the swimbladder. The lag in the rise of the oxygen curve in comparison with the carbon dioxide curve shown in fig. 1 in part I will be clearly understood.

The above explanation leads to the following predictions:
(1) The hydrogen ion concentration of the red gland will be increased by the activation of the gland. (2) When the percentage of carbon dioxide in the swimbladder is raised, a certain amount of oxygen is expected to be forced out of the blood into the bladder.

HALL (1924, Biol. Bull. 47) dialyzed the gland with distilled water and obtained lower pH value for the dialysate of the activated gland than that of the non-activated. In the present investigation the hydrogen ion concentration of the venous blood coming out of the red gland was determined. For the determination, HAWKIN's micromethod (1922, J. Biol. Chem. 57) was employed with minor modifications. The results show that blood running out of the activated gland has somewhat lower pH value than the normal venous blood. When 5 cc of the gas was removed from the swimbladder the pH value of the blood mentioned above averaged 7.49 as compared with 7.71 of the control.

The second prediction was also approved by the following experiment. 4 to 5 cc of carbon dioxide was injected by a syringe into the swimbladder. After complete mixing, the same amount of gas as that injected at first was removed, so as to give the normal buoyancy in order not to activate the red gland. This gas was immediately analysed with an assumption that its composition is practically the same as that left in the bladder. After the intervals of one hour and three hours, the gas in the bladder was analysed again. The excess carbon dioxide was proved to have decreased quite rapidly during these intervals, while oxygen made a slight

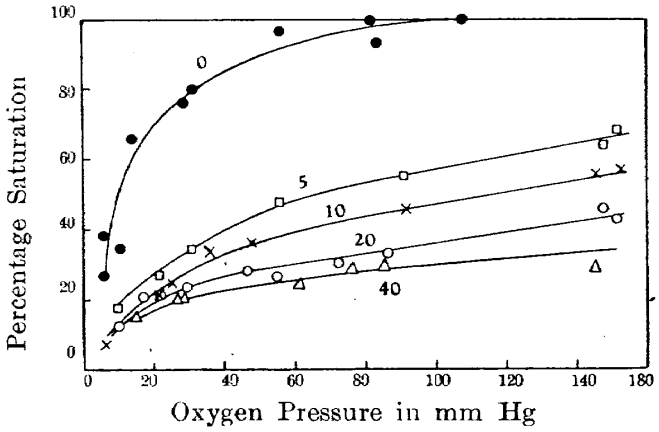

Fig. 1. Effect of carbon dioxide on the oxygen dissociation curve of *Monacanthus* blood.

increased.

As is mentioned above, the liberation of oxygen from the red gland can be attributed to the effect of the hydrogen ion concentration on the dissociation of oxyhemoglobin. KROGH and LEITCH (1919, J. Phyiol. 52) have found that the oxygen dissociation of fish hemoglobin is especially affected by carbon dioxide. Because of a rather unsatisfactory method used by them the data are not reliable. Hence the effect of carbon dioxide on the oxygen dissociation curve was studied directly on the blood *of Monacanthus*. The method for obtaining the dissociation curve was the one generally adopted hitherto. In fig. 1, five dissociation curves corresponding to the partial pressure of carbon dioxide of practically 0, 5, 10, 20 and 40 mm Hg respectively are arranged from left to right. From this figure it can easily be noticed that the oxygen combining capacity markedly diminishes by an increase in the tension of carbon dioxide. This is true even when the partial pressure of oxygen raises to about 160 mm Hg, though in mammalian blood the effect is noticeable only when the partial pressure of oxygen is low. This fact is very important to suggest a condition that oxygen may be liberated into the swimbladder in which the tension of oxygen is normally found comparatively high in the present material.

The fuller description of the present note will appear in the Journ. Faculty of Science, Tokyo Imperial University.