The oxygen consumption of some tissues from hypophysectomized goldfish, Carassius auratus L.[1]

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Summary. Hypophysectomy has no effect on the O_2 consumption of minced brain and white muscle tissue, while liver tissue shows a marked reduction. This reduction in liver O_2 consumption is attributed to the increased glycogen content that follows hypophysectomy which has the effect of increasing the nonmetabolizing dry weight component of the cells.

Hypophysectomy of mudminnows, Umbra limi[2] and goldfish[3] is followed by a reduction in whole animal routine oxygen consumption. Hanson and Stanley concluded that this reduction reflected 'a decrease in general energy use', whereas Johansen and Gomery suggested that the reduction in oxygen consumption reflected a reduced level of spontaneous locomotor activity and/or a reduction in cellular respiration.

Visual observations of hypophysectomized goldfish suggests that they are indeed less active than fish with intact pituitaries. This relative inactivity could account for the reduction in whole animal routine oxygen consumption, but a reduced level of tissue respiration could also result in less energy available for locomotor activity. Accordingly, the following study was undertaken to determine the level of respiration of brain, white muscle and liver tissues of hypophysectomized goldfish.

Materials and methods. The source, size, holding temperature, feeding, and surgical procedures were the same as those previously described[4]. The incubation medium of about 270 mosm l^{-1}, pH 7.2 consisted of 6.67 g NaCl, 0.37 g KCl, 0.14 g $MgCl_2$, 0.10 g Na_2HPO_4, 0.16 g $NaHCO_3$, 0.33 g $CaCl_2$, and 2.5 g glucose dissolved in 1.0 l of glass distilled water. Oxygen consumption was recorded at 20 °C with a Clark-type oxygen microelectrode (Yellow Springs Instrument Co., Yellow Springs, Ohio, USA) connected through a 0.8 V polarizing source to a Sargent model SRG recorder (Sargent-Welch Scientific Co., Toronto, Canada).

In practice the fish was killed by transecting the brain stem and the appropriate tissue (complete brain, $^1/_3$ of the liver or portion of white epaxial muscle anterior to dorsal fin) quickly excised and minced with a scalpel blade. The minced tissue along with 2.0 ml of incubation medium was placed into a respiration cell and allowed to equilibrate for 5 min with gentle stirring and aeration. Following equilibration the oxygen electrode was placed into the respiration cell taking care to exclude all air bubbles and, with continuous stirring, oxygen consumption was monitored for 15 min. Only 1 tissue per fish was used. Care was taken to finely mince the tissues so as not to set up a diffusion gradient which could interfere with the recording of oxygen uptake[5]. The electrode was calibrated after every 4 to 5 tissues.

Following the recording of oxygen uptake the contents of the respiration cell were poured into tared dishes and dried to constant weight. A correction factor was determined for the added solutes of the incubation medium. The data were analyzed using a two-tailed, Student's t-test.

Results and discussion. The O_2 consumption values for brain and liver (table) are not too dissimilar from those of Ekberg[6] and Kanungo and Prosser[7] though direct comparisons are not possible due to many differences in the experimental procedures. The present values for white muscle tissue are lower than those previously reported[3] which were based on 2 preliminary experiments.

The significant feature in this study is the effect of hypophysectomy on tissue respiration. Only in the case of liver tissue is there a statistically significant decline of 40–47% in oxygen consumption following hypophysectomy. The liver of hypophysectomized goldfish undergoes marked changes[4] one of which is the increase in glycogen concentration by about 30%, but since the liver also enlarges the total glycogen content increases 2 to 3 times. Therefore, the decrease in oxygen consumption on a dry weight basis is likely an artifact of the increased inert glycogen. Expressed on a protein basis there would likely be little or no change in respiration since there is no change in total protein content[4]. Thus it appears that, in the goldfish, hypophysectomy is without any direct effect on the oxygen consumption of brain, white muscle and probably liver tissue.

Sordahl et al.[8] have shown that there is no change in the oxygen consumption of liver mitochondria of hypophysectomized cats, though Houssay[9] found a reduction in the basal metabolic rate of hypophysectomized dogs. The oxygen consumption results for hypophysectomized goldfish are similar to those of the above mammals in that routine whole animal oxygen consumption was reduced, but there was no change at the tissue level. Thus it appears that the lower rate of goldfish routine oxygen consumption is not a direct function of a lower rate of tissue oxygen consumption, but of other as yet undetermined factors.

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2 R. C. Hanson and J. G. Stanley, Comp. Biochem. Physiol. *33*, 871 (1970).

3 P. H. Johansen and J. D. Gomery, Can. J. Zool. *51*, 1289 (1973).

4 R. M. Walker and P. H. Johansen, Experientia *31*, 1252 (1975).

5 M. E. LeFevre, H. R. Wyssbrod and W. A. Brodsky, BioScience *20*, 761 (1970).

6 D. R. Ekberg, Biol. Bull. *114*, 308 (1958).

7 M. S. Kanungo and C. L. Prosser, J. cell. comp. Physiol. *54*, 265 (1959).

8 L. A. Sordahl, J. C. Hall and P. L. Stefko, J. biol. Chem. *238*, 474 (1963).

9 B. A. Houssay, Endocrinology *18*, 409 (1934).

Tissue oxygen consumption of sham-operated and hypophysectomized goldfish 4 weeks (A) and 9 weeks (B) after surgery expressed in μmoles O_2 g^{-1} (dry wt) min^{-1} (mean ± SE, sample size in brackets)

	Brain	White muscle	Liver
A. Sham-operated	1.575 ± 0.052 (6)	0.111 ± 0.010 (7)	0.454 ± 0.046 (6)
Hypophysectomized	1.613 ± 0.078 (5)	0.113 ± 0.016 (7)	0.277 ± 0.039 (7)*
B. Sham-operated	1.690 ± 0.091 (5)	0.157 ± 0.010 (5)	0.555 ± 0.069 (4)
Hypophysectomized	1.609 ± 0.067 (5)	0.151 ± 0.026 (5)	0.292 ± 0.022 (5)**

* $p < 0.05$; ** $p < 0.01$.