THE ENERGY SOURCE OF THE MUSSEL (MYTILUS EDULIS) DURING OXYGEN LACK.

By

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With 2 figures in the text.

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Introduction.

It has been pointed out in the previous paper (MALOEU F, this journal) that, when in distilled water, the mussel maintains its valves so tightly closed that there is no exchange of water or dissolved gases between the interior and exterior. Such a condition can be maintained for 2—4 days at ca. 18°C. This is tantamount to an existence without oxygen (at least from the external medium); for, it can be shown that the amount of oxygen dissolved in the sea water enclosed within the valves will be utilised within an hour or less.

It has been known for several years that several lamellibranchs are capable of withstanding an absence of oxygen for a considerable period, especially at low temperatures (Mya, Collip ’21; Saxidomus, Paphnia, and Mya, Berkeley ’21 and ’23; Ostrea, Galtsoff and Whipple ’31). While Lesser (’09 and ’09—’10) found that glycogen is utilised at a greater rate in earthworms during the absence of oxygen than with the presence of this element, Berkeley (loc. cit.) observed that "in the cases of Paphnia staminea and Mya arenaria the disappearance of glycogen was no greater in the absence or presence of air, other conditions being equal. In the case of Saxidomus giganteus more glycogen disappeared under anaerobic than aerobic conditions but the amount consumed in the former case was insufficient to account for the carbon dioxide produced, ...".

Is there, during the period of oxygen-absence, an oxidation of some sort in the animals? Because of some evidence of a meager kind, Berkeley (’23) believed that the crystalline style may be such a source. Such an attitude is untenable for it has already been noted that the style disappears during starvation even in the presence of an ample amount of dissolved oxygen (see Mitra ’01, Nelson ’18, Edmondson ’20, and Allen ’21), and hence not solely during anaerobiosis (Berkeley ’23 and Nozawa ’29). Above all, Coupin (’00) had found that the style contains no sugars or fats and only a trace of protein and when dried weighs only 0.004 gm. — an insignificant amount of material to take

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the place of oxygen as an oxidant. The function of the style seems to have been best grasped by Nelson — it is "of great importance in separating food from foreign particles and in serving as a substitute for peristalsis". In *Mya* (Collip), at least, such anaerobiosis is not aerobic life in the strict sense of the term, for, these mollusks build an oxygen debt during the absence of oxygen and the greater the stay without oxygen, the greater the oxygen debt.

It appears, therefore, from what has been written on the subject, that during the anaerobiosis of lamellibranchs there is a hydrolysis of carbohydrate (glycogen in some cases, at any rate) to lactic acid much as during the muscular activity of other animals. Whether this is the sole or main manner of energy liberation during oxygen lack has not been determined. Undoubtedly a most important factor allowing the prolonged existence of the animals in the absence of oxygen is the fact that a constant $p_\text{H}$ is maintained by a utilisation of the large store of shell-carbonate (Collip '20, '21).

**Methods.**

The manner of attack was to slice pieces of mussel tissue with a sharp razor blade and measure their rates of CO$_2$ production, in the absence of oxygen, in amphibian Ringer's (double concentration) and in the Ringer's plus cyanid, ethyl urethane, or monoiodo-acetic acid. In this way it is possible to discover what fraction of the CO$_2$ produced is due to the action of anaerobic oxidases (might liberate oxygen from glycogen with the formation of fat), dehydrogenases, and glycogenases. The slices of tissue were about 2 c.mrn. in volume and spread out on the wire mesh of the respiratory chamber previously described (Maloueuf '36 and the preceding papers). One lateral half of a full-sized mussel was used in each case. The oxygen was displaced from the medium by a strong stream of nitrogen. The amount of oxygen remaining in the medium after sealing of the respiratory chamber was always very close to 0.025 vol. per cent (analysis by the Van Slyke-Neill apparatus). This was completely consumed within the first hour. During this period the amount of CO$_2$ which would be liberated as a result of the oxygen consumed was subtracted from the total amount of CO$_2$ discharged (knowing that the R.Q. = ca. 1, see Maloueuf, previous paper). When KCN was used, no such correction was necessary chiefly because the KCN, in contact with the catalytic action of the mercury of the respiratory chamber, rapidly consumes the oxygen present with the formation of $K - C = N = O$. The effects of chloretone could not be tested because this compound reacts with the NaOH, used in analysis, with the discharge of gas bubbles into the reaction chamber. Ethyl urethane was used as a substitute narcotic.

In the supplementary studies on the effects of oxygen pressure on the rate of oxygen consumption of sliced mussel tissue, in order to permit maximum diffusion of oxygen into the tissues, only a single layer (about 4 gms. wet weight) of slices was placed on the iron mesh. When there were two or three layers the rate of oxygen consumption, at a given oxygen pressure (fig. 2, +), was very much less than when only a single layer was used (fig. 2, ○). To insure that there was an approximately equal representation of the various tissues in each case a whole lateral half was sliced up and well mixed in a container before drawing a sample into the respiratory chamber. The tissues were enclosed in the respiratory chamber for not over two hours.