Oxygen consumption of the frog gastric mucosa

The gastric mucosa of the frog *in vitro* maintains an electrical potential difference and secretes HCl for many hours. Both electrical and secretory activity are strongly dependent on respiration, disappearing quickly after removal of external oxygen[1]. The molar ratio of HCl secreted to O_2 consumed by the mucosa has been used to evaluate various proposed mechanisms for the production of acid[2]. Previous estimates of the ratio[3,4] have been based on the manometric measurement of O_2 consumption in the absence of external CO_2, although the latter gas is necessary for maximal acid secretion[5]. This method also precluded the detection of changes in electrical activity and any associated changes in O_2 consumption.

These experimental difficulties may be eliminated by the use of the polarographic method for the measurement of the O_2 concentration in the solutions bathing the isolated mucosa. In our experiments the mucosal membrane was mounted between two Lucite chambers, one containing a modified Krebs solution in contact with the serosal surface and the other chamber containing a similar solution, without bicarbonate buffer, in contact with the mucosal surface. These solutions had been equilibrated with 95 % O_2 + 5 % CO_2 and pure O_2 respectively. The concentration of O_2 in each solution was measured by an O_2 electrode[6] and always exceeded 50 % saturation. An electrical circuit permitted the continuous measurement of the current delivered by the mucosa into an external resistance of zero, *i.e.*, the short-circuit current. Acid secretion was measured by electrometric titration *in situ*. The solutions were stirred magnetically and were closed to the atmosphere. Measurements of the rates of acid secretion and O_2 removal from the two solutions were made for two to four successive intervals of 50 to 60 min each.

It was found that the rates of removal of O_2 from the two solutions were comparable; these two values have been added to find the total rate of O_2 consumption. All results have been expressed in μmoles or μequiv./mg dry wt. of mucosa/h. Table I lists the means, with corresponding standard errors, for 42 periods during which the mucosae were secreting spontaneously, and for 15 periods during which the mucosae were stimulated by $5 \cdot 10^{-5}$ *M* histamine.

TABLE I

	Acid secretion (μequiv./mg/h)	*Short-circuit current (μequiv./mg/h)*	*O_2 consumption (μmoles/mg/h)*
Spontaneous (42 periods)	0.079	0.362	0.139
S.E.*	± 0.010	± 0.023	± 0.011
Stimulated (15 periods)	0.150	0.360	0.168
S.E.*	± 0.021	± 0.027	± 0.015

* Standard error.

As found previously[7], the short-circuit current in these experiments does not depend on the rate of acid secretion. This finding makes possible an estimate of the ratio $\Delta H/\Delta O_2$ from Table I. Using the means of acid secretion and O_2 consumption, $\Delta H/\Delta O_2 = 0.071/0.029 = 2.4$.

In an alternate analysis, it was assumed that the data could be fitted to an equation of the form:

$$\text{Oxygen consumption} = A + k_1 \text{ (acid secretion)} + k_2 \text{ (short-circuit current)}$$

The constant A represents the O_2 consumed in processes other than those responsible for current or acid production. The values for k_1, k_2 and A were obtained by a conventional, least-squares technique[8]. A preliminary calculation showed that the use of histamine did not significantly affect the value of A, and the 57 experimental periods were combined to yield the values:

k_1 0.41 $\pm$ 0.08 (standard deviation)
k_2 0.27 $\pm$ 0.04
A 0.01 $\pm$ 0.05

By the use of the t test, in which $t_1 = 0.41/0.08 = 5.1$ and $t = 0.27/0.04 = 6.7$, we may virtually exclude the possibility that the O_2 consumption is independent of acid secretion ($k_1 = 0$) or short-circuit current ($k_2 = 0$). The value obtained for A indicates that nearly all the respiration is related to secretory and electrical activity.

The reciprocal of k_1, $1/0.41 = 2.4$, gives $\Delta H/\Delta O_2$ at constant short-circuit current; the reciprocal of k_2, $1/0.27 = 3.7$, yields Δ (short-circuit current)$/\Delta O_2$ at constant acid secretion. CRANE AND DAVIES[3] found for the ratio $\Delta H/\Delta O_2$ values up to 13, with only one-third of the measurements yielding a value less than 4. DAVENPORT[4] has, however, reported a value of 2.15 for this ratio. The present results (and those of DAVENPORT) are consistent with the hypothesis that secreted H^+ is derived by a "redox" mechanism from substrate hydrogen (*cf.* ref. 9). A similar mechanism, presumed separate[10], may give rise to the transport of Cl^- manifested by the electrical current. These results leave open the question of linkage between the two mechanisms.

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