Composition of Float Gases of *Physalia physalis*.* (26724)

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Recent communications(1,2) have described the float gases of *Physalia physalis* and have called attention to the presence of significant concentrations of carbon monoxide in this gas. Wittenberg(2) has suggested a possible route for biological synthesis of carbon monoxide from the amino acid serine. This communication describes a series of analyses of the float gases of *Physalia*, taken directly from living animals under nearly optimal conditions, and an experiment to show how the composition of the float gas is corrected after experimental modification.

Materials and methods. Living specimens of *P. physalis* were collected from the ocean beach on Key Biscayne, Fla., on days when the winds were favorable during the period of their seasonal abundance(3). It should be emphasized that all animals for this study were taken from outside the surf line before they had been stranded on shore and were transported directly to the laboratory with a minimum of handling. Gas was aspirated into special gas-sample bottles immediately upon arrival at the laboratory and stored under slight positive pressure in the same bottles. Gas samples were analyzed in the Scholander ½cc Gas Analyzer. A series of analyses for oxygen and carbon dioxide were made using the separate hydrosulfite-anthraquinone sulfonate and KOH absorbents described by Scholander(4). Since carbon dioxide was negligible in float gases, these absorbents were replaced by alkaline pyrogallate to absorb both oxygen and carbon dioxide together. Carbon monoxide was absorbed by Scholander's modification of Winkler's solution(5). The sample was transferred without contamination to the analyzer and allowed to equilibrate. The oxygen and carbon dioxide were absorbed by alkaline pyrogallate. The reaction chamber was then washed twice with acid-rinsing solution and rinsed one or more times with distilled water. Carbon monoxide was determined by introducing another sample of the same gas and absorbing the carbon monoxide, oxygen, and carbon dioxide with Winkler's solution, and subtracting from this value the percentage of oxygen and carbon dioxide which had already been determined. At least 2 complete analyses were made of each gas sample, and unless the results agreed within 0.1% the analyses were discarded and the sample analyzed again. After analysis of carbon monoxide the apparatus was again washed and rinsed completely in preparation for analysis of the next sample.

To demonstrate the capabilities of the gas gland of *Physalia*, one vigorous mature specimen was partially deflated by withdrawing gas from the pneumocyst and replacing it with pure carbon monoxide. The animal was then maintained in aquarium of circulating aerated sea water. A floating polyethylene ring prevented the specimen from adhering to the wall of the aquarium. This animal remained in good condition during the experiment.

Pressure within the float of mature vigorous specimens was measured by inserting a cannula connected with an inclined water manometer directly into the float cavity.

Certain specimens were partially deflated and subsequently observed for periods up to 36 hours. None was observed to reinflate.

In other experiments it was thought advisable to replace the gases of the float completely. To this end the pneumocyst was flushed 3 times with tank carbon monoxide. Although great care was exercised to avoid over-inflation no animal subjected to this treatment survived 24 hours.

Results and discussion. Table I describes the composition of the float gas in 12 individual *Physalia*. The composition varies considerably with various functional states of the animal. Carbon monoxide was the most

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TABLE I. Composition of Float Gas of *Physalia*.

Sample	% O_2	% CO	% N
1	16.976	6.074	76.950
2	16.808	5.412	77.780
3	17.563	2.620	79.817
4	16.277	2.660	81.063
5	18.749	1.285	79.967
6	17.563	2.626	79.966
7	16.277	2.660	79.811
8	19.320	.712	79.968
9	20.775	.211	79.014
10	17.437	3.371	79.192
11	14.723	5.552	79.725
12	20.893	1.246	77.861
Avg	17.78	2.89	79.26

variable of the float gases. This observation lends support to the suggestion that the gas originally secreted by the gas gland is pure carbon monoxide. The structure of the float appears to minimize exchange between its contained gas and the atmosphere. It should be recalled that this apparently simple structure contains 2 mesogleal layers, 2 ectodermal layers, 2 endodermal layers, and an extension of the gastrovascular cavity, through which fluid circulates, and that it is lined with a chitinous cuticle which must further impede gas exchange. These structural conditions suggest that diffusional exchange between gases of the float and the ambient air must be minimal.

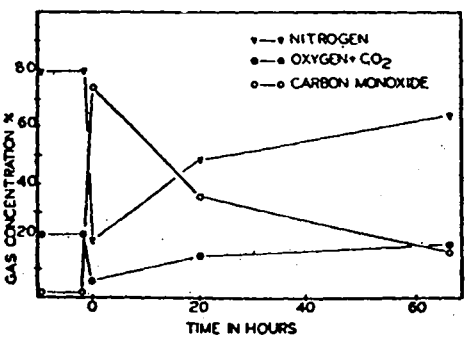

FIG. 1. Composition of *Physalia* float gases during a typical flushing experiment. At 0 hr approximately one-third of total gas volume was replaced by carbon monoxide.

Pressure within the float, measured directly, was from 5 to 10 mm Hg above atmospheric. It is unlikely that this is sufficient to establish a significant outward diffusion gradient. Since the partial pressures of component gases within the float normally equal or exceed those in ambient air, significant inward diffusion, postulated by Wittenberg(2) is also unlikely.

Summary and conclusion. The float gases of *Physalia* contain carbon monoxide. The amount varied from 0.21% to 6.07% of the total. It is suggested that variations in carbon monoxide content may reflect differing functional states in the organism. The composition of the gas in the pneumocyst may change qualitatively and quantitatively in 24 hours. When the float was inflated with pure carbon monoxide this gas was diluted approximately 4-fold during the following 66 hours. During this same period the concentration of oxygen and carbon dioxide increased about the same extent. Concentration of nitrogen in the float gas increased 3-fold during this same period. These changes in composition of float gases could result either from active secretion from the gas gland or from passive diffusion through the wall of the pneumocyst. Structural considerations make this latter possibility considerably more remote than active secretion by the gas gland.

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