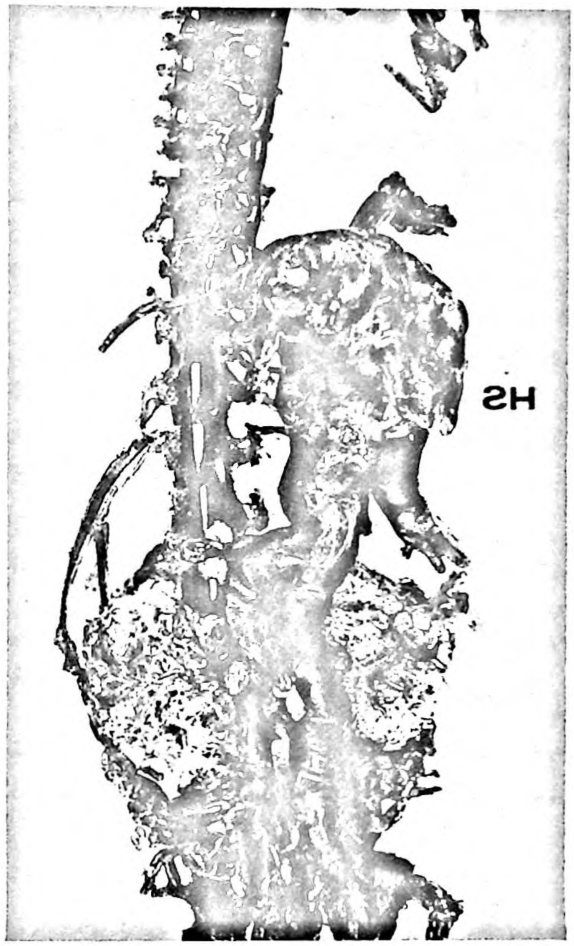

Figure 1

1968 #5

PULMONARY CIRCULATION DURING SIMULATED DIVING IN THE HARBOR SEAL, Phoca vitulina

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The present study was undertaken to measure intravascular pressures and blood flow in the pulmonary circulation of seals during diving.

Experiments were performed in nine animals, approximately four months old and weighing about 25 kg. In three seals, premedicated with Sernylan® (0.3 mg/kg), thoracotomy was done under sterile conditions using local anesthesia (2% xylocaine). An electromagnetic flowmeter (Biotronics) was implanted around the main pulmonary artery and polyethylene catheters were implanted in the main pulmonary artery and left atrium. The animals resumed activity on the second post-operative day and records of pressure and flow were obtained during the subsequent five to ten days (Fig. 1). "Diving" responses, characterized by sudden and profound bradycardia, could be obtained with ease by applying a cold, wet towel to the snout of the animal. The average duration of the stimulated dive was 60 seconds, but it could be prolonged without difficulty to

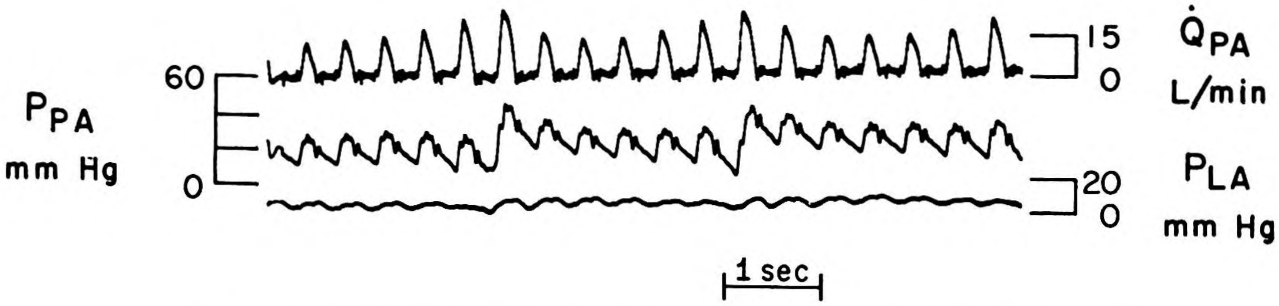

Figure 1. Representative records of pulmonary blood flow ($\dot{Q}_{PA}$), pulmonary arterial pressure (P_{PA}) and left atrial pressure (P_{LA}) in a harbor seal, during quiet breathing.

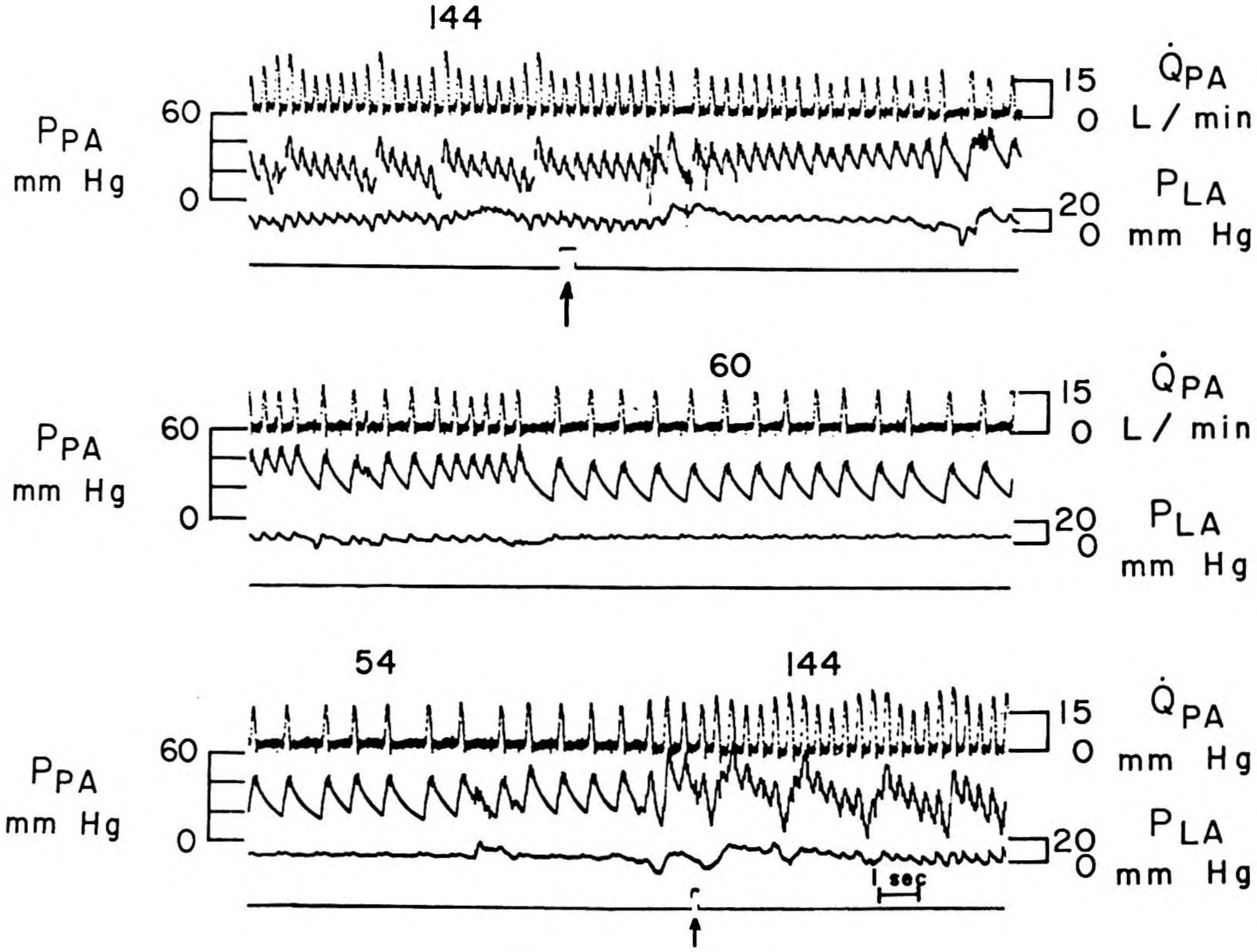

Figure 2. Continuous record of blood pressures and flow in the pulmonary circulation during a simulated dive of approximately 60 seconds duration. The arrows signal the onset and end of the diving period. The numbers above the tracings represent average heart rates. Although the heart rate falls dramatically (without an appreciable change in stroke volume) pulmonary arterial pressure (P_{PA}) is maintained at normal levels. Left atrial pressure (P_{LA}) is essentially unchanged throughout the diving period. $\dot{Q}_{PA}$ = pulmonary blood flow.

three or more minutes. Heart rate decreased from a control rate of about 120 beats per minute to an average of 50 beats per minute during the simulated diving, and returned promptly to control levels after the towel was withdrawn. Stroke volume remained essentially unchanged, except for a slight decrease toward the end of the more prolonged simulated dives. Pulmonary artery systolic, diastolic and mean pressures averaged 30, 17 and 25 mm Hg respectively, and the mean pressure tended to remain unchanged or even rise a little during the simulated dive (Fig. 2). The rate of pressure drop, after the dicrotic notch, in the pulmonary artery pressure pulse was greatly prolonged during simulated diving, suggesting an increase in resistance to flow. In order to investigate whether there were preferential pathways of blood flow in the lungs during diving, scanning of formalin-fixed lung slices of uniform thickness, after intravenous injection of ^{131}I taged albumin aggregates was done in four seals: two served as controls and two were tested during diving. There was no gross inhomogeneity of perfusion in the four lungs studied by this method.

It has long been known that the systemic blood pressure of aquatic birds and mammals is maintained at normal levels during diving despite a drastic fall in cardiac output. [We confirmed

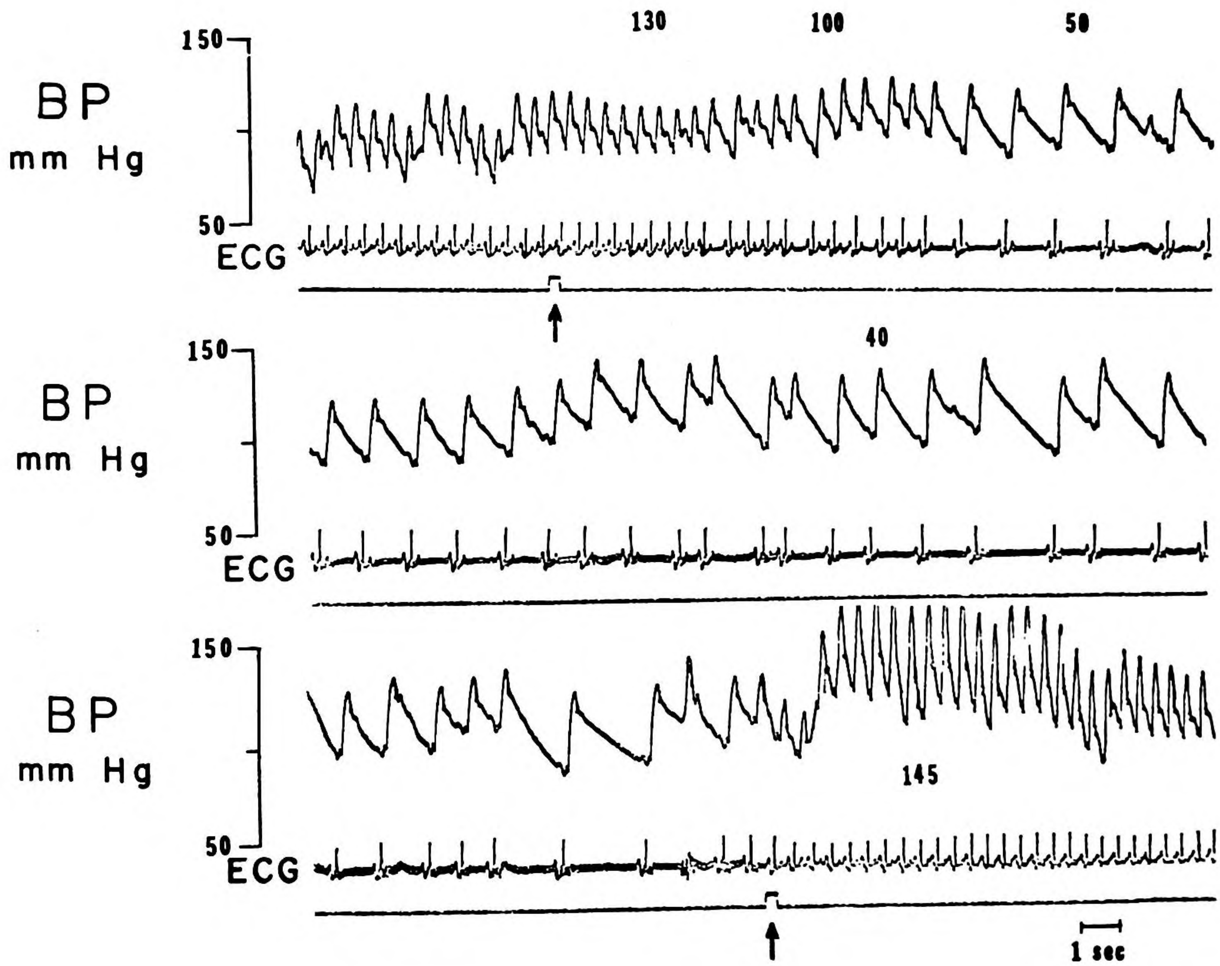

Figure 3. Continuous records of aortic blood pressure (BP) and electrocardiogram (ECG) during a simulated dive. Systemic blood pressure is maintained and even rises toward the end of the dive, despite a severe reduction in heart rate. The arrows signal the onset and end of the diving period.

this observation in two seals (Fig. 3).] The consensus has been that this response is due to profound peripheral vasoconstriction and consequent reduction in the effective size of the systemic circulatory bed. The present experiments strongly suggest that the pulmonary circulatory bed, similarly, is severely reduced in size during diving. Whether mechanical or vasomotor effects are predominantly involved remains to be clarified.

1968 #6

OSMOREGULATION IN Oniscus asellus

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The most serious problem facing terrestrial arthropods is water conservation. In arachnids and insects, the key to attaining a full degree of terrestrialness was the development of a surface wax layer to restrict water loss from the body. Terrestrial crustacea and myriapods lack such a layer and are essentially cryptozoic; they rely heavily on behavioural mechanisms designed to restrict them to cool damp regions under logs and stones. Although these behavioural mechanisms have been studied extensively, very little is known about the osmoregulatory capacity of these cryptozoic animals. Osmoregulation was, therefore, studied in the terrestrial isopod, Oniscus asellus, which was collected in the vicinity of the laboratory. Animals were kept in small glass dishes containing damp filter paper and pieces of carrot.

The first experiment involved testing the osmoregulatory capacity of animals under the stress of varying degrees of desiccation. Animals were placed individually in small gauze-covered containers and dehydrated over $CaCl_2$. Rate of water loss was very high (10% body weight/hr at 20-22° C) and the animals died after 3 hours. This rapid rate of transpiration is to be compared with that found in insects such as Tenebrio where the presence of a waterproofing wax layer reduces transpiration (0.05% body weight/hr at 23° C). When dehydrated, Oniscus displayed no capacity to regulate its internal milieu. The normal osmotic pressure (475 milliosmoles - range 420-510) increased in proportion to the increase in water loss from the animal. Despite this large increase in osmotic pressure, the animals appeared normal; the only obvious response to desiccation was an increase in activity. A similar response has been noted in behavioural studies on terrestrial isopods and is believed to have adaptive significance in that it plays a part in the orientation mechanisms which are directed toward aggregating the animals in moist environments. In this first experiment the severity of the osmotic stress and the large scatter of points (due partly to the wide range of osmotic pressures found in the normal population) may have masked a limited osmoregulatory capacity. Consequently, a more detailed study was made of those organs which may function in osmoregulation.

The antennary glands represent the major organs of osmoregulation in Crustacea. Careful dissection of the head capsule of Oniscus failed to reveal these organs even after injecting the animals with lissamin green or phenol red. The functional significance of these glands was assessed by following the fate of the above dyes when injected into the animal. Phenol red (200 μg/g) was completely cleared from the blood in approximately 30 minutes and lissamin green (400 μg/g) in about 45 minutes. The animals were kept throughout the post-injection time on clean filter paper and there was no evidence that dye was being eliminated from the body. Sub-