rate. The average PD before carbachol was -1.4 mv (minus means nutrient negative). Addition of carbachol to the nutrient resulted after a latent period of 3 to 7 min., in the PD becoming more negative. the PD peaked (average PD = -5.2 mv at peak) and then gradually became more positive and leveled off around -2.4 mv. Carbachol resulted in a decrease of the resistance from an average value of 232 ohm cm^2 to an average of 150 ohm cm^2. Addition of thiocyanate to nutrient (20 mM) caused a marked reduction of the H^+ rate, an average increase of the positivity of the PD by 7.5 mv and an increase in the resistance. Preliminary experiments reveal that thiocyanate when added to the secretory side inhibited H^+ secretion and resulted in a much smaller increase in the positivity of the PD. After the H^+ rate was reduced to about zero further increases in thiocyanate on the secretory side resulted in an increase in the negativity of the PD. In a typical experiment with a thiocyanate nutrient and a Cl^- secretory solution the PD was +16 mv and with a thiocyanate secretory and a Cl^- nutrient the PD was -16 mv. These effects of thiocyanate on PD could be interpreted to mean that the gastric mucosa is more permeable to thiocyanate than to Cl^- in the net transport of charge sense.

1963 #29

THE STRUCTURE OF GILLS

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In order to obtain a thorough knowledge and understanding of gill structures, the following fishes were fixed and prepared for electron microscopy: A) Agnatha: hagfish. B) Condrichtyes: dogfish. C) Osteichthyes: 1) marine: pollock, fundulus, longhorn sculpin; 2) brackish: fundulus; 3) fresh water: catfish, eel, goldfish, fundulus. The gills of these fishes are being studied by means of both phase contrast and electron microscopy. In particular, the following structures are analyzed: a) surface epithelium, secretory and excretory cells; b) sinusoids of the gill lamellae; c) connective tissue components such as fibroblasts, cartilage, basement membranes; d) vascularization of the gill filament: afferent-efferent blood vessels, lymphatics, and lymphoid tissue.

1963 #30

CARDIAC OUTPUT DURING DIVING IN THE HARBOR SEAL, Phoca vitulina

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The adaptive mechanisms that permit prolonged diving in mammals have been of great interest. It is well known that these adaptations involve circulatory readjustments so that blood flow to critical areas such as brain are maintained. The occurrence of bradycardia in response to diving has been well documented in the seal. Indirect evidence has suggested a generalized arterial constriction in all areas except the brain during diving. Because of technical problems, successful measurements of cardiac output during diving have not been reported nor has there been reported direct evidence of generalized arterial constriction. In the present study the Ham-

ilton-Stewart dye dilution technique was adapted permitting such measurements to be made in the seal. Fox green dye was used as an indicator dye, and an automatic recording continuous-flow photometer was employed to record the dye concentration curves in arterial blood. Validation of this technique was obtained by duplicate measurement of cardiac output by dye dilution and by direct Fick while the seal was breathing ambient air.

The results obtained were as follows. The cardiac output abruptly dropped at onset of diving from approximately 4 L/min to 0.4 L/min. This decrease was roughly proportional to the decrease in heart rate so that stroke volume did not change significantly. Dye injected into peripheral veins during diving did not appear in the central circulation or the arterial blood, indicating directly a cessation of blood flow in the flippers. With the termination of diving, heart rate and cardiac output returned at first to above basal values and then returned to basal values.

The rate of blood flow during diving is quantitatively consistent with myocardial plus cerebral blood flow. The restriction of blood flow to these organs permits O_2-dependent metabolism to continue in these key areas and thus permits survival despite loss of external O_2 supply.

1963 #31

CARDIAC OUTPUT AND GILL GAS EXCHANGE IN Squalus acanthias

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A number of techniques have been employed to estimate cardiac output in fish. These techniques have been handicapped by two factors: (1) the lack of precise techniques and (2) the necessity for nonphysiological circumstances during the measurements. In the present studies these handicaps were overcome by modifying the Hamilton-Stewart dye dilution technique so that it could be applied to the marine elasmobranchs, Squalus acanthias.

A technique was devised which permits the insertion of a catheter in the dorsal aorta through a simple needle puncture. The precise identification of the location of the catheter could be validated by the O_2 content of the blood, the pulsatile nature of the blood flow, and anatomical identification by direct inspection after completion of the studies. This intra-aortic catheter permitted blood to be sampled at a rate consistent with the inscription of an accurate dye dilution curve. Venous injection of Fox green dye was accomplished by a single needle puncture through the skin into the ducts of Cuvier. Blood obtained from the ducts of Cuvier was considered representative of mixed venous blood. O_2 consumption and CO_2 production were calculated by multiplying appropriate arterial and venous differences by the cardiac output. RQ was calculated from these values. This technique allowed the studies to be performed with the fish virtually unrestrained and in approximately normal physiological status.

A total of 15 fish, weighing from 2.6 to 7.0 kg, were studied. The following data were obtained. Mean resting CO was 1.53 L/kg/hr. CO appears to be proportionally greater per unit weight in smaller fish. CO increases with increasing H_2O temperature up to 20°C, where CO falls. Basal oxygen consumption averaged 37.6 mM/kg/hr. CO_2 production averaged 28.7 mM/kg/hr. RQ averaged 0.92.