period mentioned above. The initial mating in one case was with the white eye mutant and in the other case a white eye crossed with wild. It was interesting to note that these mutant crosses survived and successfully reproduced, with the chemical added, whereas wild fly cultures generally died out in one or two generations. This was true regardless of changes in the barometric pressure. In fact it was very difficult to obtain an F_1 from wild flies with the added protocatechuic acid. The coefficient of correlation for the white eye mutant is 0.67, and for the mutant × wild type cross, 0.76; both curves are significant at the 95-percent confidence level.

Placing the cultures in an electric field appeared to have a different effect on the progeny yield. The culture bottles were 11.5 cm high, and 4.8 cm in diameter. Semicircular electrodes were formed from copper sheeting (0.05 cm thick) and mounted on 0.5 cm thick plexiglass bases. The electrodes were 8 inches high and contacted diametrically opposite sides of the bottles. The separation at the sides of the copper plates was 2.5 cm. A 12×10^3 volt potential was applied across the electrodes with a power supply with full-wave rectification. Because of the shape of the electrodes and the inserted bottle, it was difficult to determine the exact field strength inside the bottles; however, by making some simplifying assumptions, the electrostatic field strength was estimated to be 7×10^2 coul.

The progeny yields of cultures in the electric field were, on the average, higher, and the effect of barometric pressure was considerably reduced. A coefficient of correlation of 0.08 was obtained between barometric pressure and 16 consecutive wild type generations, in the electric field. The barometric pressure values were again averaged over the 72-hour interval. The electric field appears to provide a certain amount of protection and reduces the variations found outside the field.

There is one possible explanation for this electric field effect; however, this is mostly conjecture on our part. It was felt that perhaps the barometric pressure variation is really reflecting another unknown factor. This factor might be connected with variations in the terrestrial electric fields at high altitudes, which are known to affect our general weather patterns (*5*), and which might also influence the progeny yields. Flies in the electric field are, in a sense, protected or shielded from external fluctuations. It is suggested that it might be interesting and profitable to study the reactions of more complex organisms with induced carcinogenic growths, in the electric field. Humphrey and Seal (*6*) have recently shown the effects of an external electric field on the growth of tumors in mice. We are continuing our studies on the comparison of flies grown in various environments.

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7 March 1960

Observations on the Behavior of the Porpoise Delphinus delphis

Abstract. Common porpoises have been observed in January, in the area of the Hudson Canyon, feeding on fish that escaped an otter trawl. An echo-sounder also recorded, in one instance, a descent of a porpoise to a depth of 200 feet in less than 2 minutes.

On the afternoon of 2 February 1959, we had an opportunity to observe two porpoises (*Delphinus delphis* Linnaeus) feeding on fish escaping from a trawl net, and to record them at depth on an Edo echo-sounder (Navy designation AN/UQN-1B; apex of sound beam about 30° between the half-power points). The observations were made aboard the R/V *Albatross III* (cruise 126, station 10-6, lat. 39°48′ N, long. 72°28′ W, depth of water 200 feet, surface temperature 45.9°F) in the area of the Hudson Canyon. At this season in these waters the observation of this species is, in itself, worthy of note.

Immediately following the haul back of the otter trawl, two porpoises appeared and began to feed on specimens of red hake (*Urophycis chuss* Walbaum) and scup (*Stenotomus versicolor* Mitchill) that had escaped from the net. These fish were disabled and were floating belly up as a result of their air bladders being decompressed. The porpoises were circling about at the surface and usually passed by each fish at least once before turning and picking it up.

The porpoises did not appear to be the least bit alarmed by the boat or the many people moving around on deck. They passed within a few feet of the boat several times.

Both porpoises disappeared for short intervals, at which times distinctive echo sounding records were obtained. These tracings are unique in our experience; we feel, without doubt, that they represent echoes from the porpoises (see Fig. 1). Both porpoises once descended together to the bottom, a depth of 200 feet, in about 2 minutes, and returned to the surface in less time than that. One of them dived to about 150 feet shortly thereafter and stayed at that general depth for a short period before returning to the surface.

It is not uncommon for either marine biologists or commercial fishermen to observe sharks feeding on fish that have

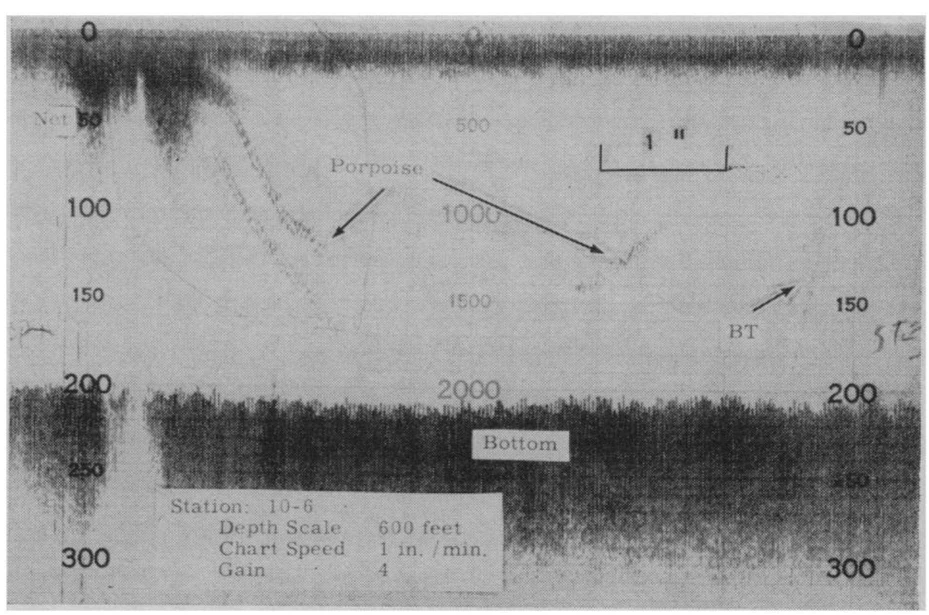

Fig. 1. Portion of echo-sounder chart showing echoes from common porpoises and from bathythermograph (BT). The vessel was hove to at the time this record was made.

escaped from trawl nets near the surface. To our knowledge, however, this is the first record of porpoises behaving similarly. Records of the depths to which porpoises descend are rare. Since porpoises presumably retain some air in their lungs when submerged, echoes of the same sort observed from fishes with sizable air bladders may be expected, in addition to echoes from the large surface area presented by a porpoise. Further observations with echo-sounders may add considerably to our knowledge of the depths to which these interesting mammals descend.

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Osmotic Pressure and Aqueous Humor Formation in Dogfish

Abstract. Comparative chemical analyses show the aqueous humor of smooth dogfish has lower concentrations of urea and trimethylamine oxide than the blood plasma. Freezing-point depression determinations demonstrate that the aqueous humor has a correspondingly lower osmotic pressure. It would appear that water entering the aqueous humor from the plasma is moving against an osmotic gradient.

Current theories on aqueous humor formation in higher vertebrates generally contend that some ion (for example, sodium) is pumped across the ciliary epithelium from the plasma, and that water then follows by osmosis (*1*). Carbonic anhydrase appears to play an important role in this process, and its action has been compared to other water balance systems, such as that in the kidney (*2*). Aqueous humor usually has lower concentrations than plasma for those constituents which cross the ciliary epithelium more slowly than water—namely, urea, glucose, amino acids, and protein. Such substances do not attain a diffusion equilibrium since the rapid drainage of the fluid is nonspecific and allows all the constituents to be removed at the same bulk rate. Consequently, a steady-state distribution ratio (aqueous concentration: plasma concentration) is reached which is less than unity and is characteristic of the particular substance. Conversely, constituents which are pumped or secreted into the aqueous humor have distribution ratios greater than 1 (*3*).

As is well known, elasmobranch fishes retain huge quantities of urea and trimethylamine oxide in their plasma, thereby elevating the osmotic pressure of the plasma above that of sea water (*4*). The study reported here was undertaken to determine the distribution ratios of these substances, since a ratio of less than 1 would result in a potentially large osmotic pressure difference between the blood plasma and the aqueous humor. For this reason, it was thought that the operative mechanisms in the elaboration of aqueous humor might be exaggerated in these fishes to compensate for the lesser osmotic contribution of urea and trimethylamine oxide in their aqueous humor.

Table 1 gives the results of chemical and physical analyses on the aqueous humor and plasma of 90 smooth dogfish (*5*). Urea and trimethylamine oxide (TMAO) reach steady-state distribution ratios of 0.93 and 0.88, respectively, the combined deficit (plasma concentration-aqueous concentration) being approximately 34 mmole/kg of water. Theoretically this could represent a difference in osmotic pressure of about 580 mm-Hg. The only component of dogfish aqueous humor in great enough excess to be osmotically important is bicarbonate ion, whose distribution ratio averaged 2.5, representing a surplus of about 9 mmole/kg of water. The higher concentration of bicarbonate ion in the aqueous humor is nullified, however, by a lower chloride ion concentration, and it would appear that an exchange of these two anions occurs, as it apparently does in other carbonic anhydrase mediated systems. The *p*H is consistently high. Sodium ion attains a distribution ratio concordant with an estimated Donnan equilibrium. Analyses on other constituents failed to demonstrate any substance or substances in great enough surplus to balance the urea-trimethylamine oxide deficit, even though more than 98 percent of the respective dry weights were accounted for.

Freezing-point depression measurements made with a Fiske osmometer (sample size, 0.2 ml) showed that the osmotic pressure of the aqueous humor was about 25 milliosmoles lower than that of plasma, suggesting that the passage of water from the plasma into the eye of this fish is against an osmotic gradient. The smallest difference found in 14 fish tested was 14 milliosmoles. The measured osmotic pressures compared favorably with those calculated from the totaled results of chemical analyses when the effect of ionic strength on activities was considered.

It seemed important to find out how similar the aqueous formation in this species is to the process in higher vertebrates. It is significant that elasmobranchs are the only fishes which possess a ciliary body (*6*). The ciliary body contains carbonic anhydrase, as it also does in mammals, and the specific inhibitor of this enzyme, acetazoleamide (Diamox), can lower the distribution ratio of bicarbonate ion to less than 1 when it is injected intravenously in the dogfish (*7*). We regard the fact that most of the distribution ratios of substances measured were characteristic of higher vertebrates (namely, an ascorbic acid excess, very low protein, and so on) as circumstantial evidence that the aqueous humor formation in these fishes follows a pattern similar to that in mammals. In addition, penetration studies (plasma to aqueous) with Na^{24} showed that the turnover rate for this isotope is about 1 percent per minute, a value similar to values found for the rabbit (*3*).

Table 1. Comparison of properties of aqueous humor and blood plasma in *Mustelus canis*.

Constituent	Fish (No.)	Concentrations: Av. (mg/100 ml)		Concentrations: Av. mmole/kg of H_2O*	
		Aqueous	Plasma	Aqueous	Plasma
Urea	11	1835	1898	320	342
TMAO	12	754	832	85	97
Sodium	12	621	613	279	288
Chloride	9	867	886	256	270
Bicarbonate	23			15	6
Potassium	4	27	31	7	8
Magnesium	4	7	7	3	3
Calcium	3	12	18	3	5
Phosphate	3	12	19	1	2
Sulfate	2	37	27	4	3
Glucose	8	120	210	7	13
Protein	6	22	2850		
Amino acids	8	15	56		
Ascorbic acid	9	2.4	.8		
Total		4331	7438	980	1037
Osmotic pressure (mm-Hg)	14			935	962
Average dry weight (mg)	4	4470	7510		
*p*H	8			7.86	7.33

* To the nearest millimole. Not corrected for Donnan effect.