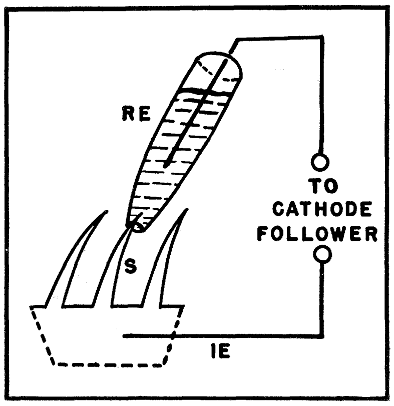

Fig. 1. Diagram of experimental preparation. *S*, chemosensory sensillum on labellum of fly; *RE*, recording electrode; *IE*, indifferent electrode.

diameter) glass tubing was drawn to a tip diameter of about 0.05 mm and filled with the solution under test for its ability to stimulate. The tube containing the solution served both as stimulator and recording electrode; it was connected to a cathode follower by a silver-silver chloride wire inserted into the large end of the tube. An indifferent electrode of silver-silver chloride wire was inserted into the crushed head of the fly. The recording electrode was maneuvered by a micromanipulator until the tip of a single chemosensory hair just penetrated the surface film of the electrode solution. Potential changes between the electrode pair were recorded by means of a push-pull cathode follower, Grass P-4A amplifier, and cathode-ray oscilloscope. A diagram of the experimental preparation is shown in Fig. 1. The impedance looking into the hair is very high, giving problems in voltage division at the grid without feedback compensation. However, it was found as a purely empirical technique that if the ground connection is left off the preparation, capacity coupling between the two grids allows them to seek their own zero grid current level and thereafter to act as high-impedance input devices. The frequency response is much narrowed by this procedure, but since we were interested only in the presence of the spikes, and not in their exact shape, the method was easy and sufficient.

The electric response from a single hair consisted either of one or both of two series of spike potentials, each series clearly originating in a single neuron. The larger spike predominated when the electrode contained salts, acids, or alcohols; the smaller spike predominated when the electrode contained sugar solution with only a trace of electrolyte. Photographs of typical spike potentials as they appear on the oscillograph screen are shown in Fig. 2. There seems to be little doubt that the two types of spikes are associated with the responses of the two neurons having processes extending to the tip of the hair. Since a fluid contact and a trace of electrolyte in the electrode are necessary for electric contact, it has not yet been possible to define the unstimulated state of the two fibers. However, there are indications that both may have a low-frequency spontaneous discharge under conditions approaching zero stimulation.

The sensitivity of both chemoreceptor cells to a variety of chemicals and also to mechanical and temperature changes have been studied in more than 50 preparations (usually with a number of individual chemosensory hairs in each preparation) and four genera of flies (*Phormia, Sarcophaga, Musca,* and *Drosophila*). In a general way, the activity of the chemoreceptor cells resembles many of the characteristics previously reported for neurons that supply mammalian chemoreceptors. Both receptor cells in a labellar hair exhibit rapid adaptation, dropping from a high-frequency discharge to a much lower steady discharge frequency within 1 or 2 sec after a chemical stimulus is applied. The interval between application of the stimulus and the first spike recorded is about 10 msec, or about one-half of the values obtained in responses recorded from neurons associated with mammalian chemoreceptors. Responses are modified by temperature changes, and both receptor cells can respond to mechanical movement of the labellar hair.

Of particular interest is the two-fiber system present in each hair. Stimuli that evoke the smaller spike elicit the positive feeding response (proboscis extension) in the intact fly, and stimuli that evoke the larger spike cause a negative, or rejection, reaction in the intact fly. Thus there is now direct evidence of a peripheral discrimination mechanism in each chemosensory hair, as postulated by Dethier (*3*) on the basis of behavioral studies. A third neuron is associated with each labellar hair, but it does not send a process to the chemosensory tip (*3*). Potentials from a third neuron have not yet been recognized in records made with the present electrode arrangement and types of stimulation applied.

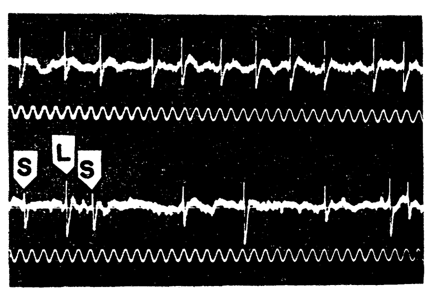

Fig. 2. Upper record: portion of a response to 0.5*M* NaCl; lower record: portion of a response to 0.1*M* sucrose plus 0.1*M* NaCl. Pointers indicate small (*S*) and large (*L*) spikes in the lower record. The time base in both records is 100 cy/sec.

A detailed description of these results has been submitted for publication elsewhere. High-impedance input devices that are designed to extend this method to new preparations and problems are now under construction.

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Geomorphic Evidences of Recent Climatic Fluctuation in the Peruvian Coastal Desert

The observations described in this paper were incidental to geomorphic studies under the auspices of the Office of Naval Research [contract Nonr-583(06)]. Although the data are incomplete, they are believed to be of sufficient interest to be placed on record for the information of archeologists and others to whose work they may be relevant, or who may have opportunity to supplement them. The locations are presented in terms of distances north of Lima, Peru, along the Pan-American Highway, as designated by marker posts along the highway.

On a limestone ridge some 300 ft high, east of the highway near kilometer post No. 716, grooving and fluting by sand blasting are conspicuous. Much of it, however, appears to predate the present. The fluted ledges show separation and dislocation along joints, subsequent to the fluting. Many of the fluted surfaces have been roughened by the superimposition of rillensteine formed by solutional etching. At a few points the rillensteine, in turn, show some smoothing by renewed sandblasting.

Between kilometer posts 235 and 250, and also at other places, irregular sheets of older eolian sand mantle many of the hill slopes, filling minor stream channels. The sand surface is dark in color and is well stabilized by a litter of rock chips and granules, suggesting immobility for a long interval of time. At several places, however, the older sand is being overridden by drifts of light-colored, fresh eolian sand, which stand in sharp contrast, and indicate renewal of eolian activity.

Although these observations were made in widely separated locations, they are consistent with one another and suggest the following climatic chronology: (i) an earlier episode of vigorous sand movement and sandblasting by wind, under climatic conditions more or less similar to those of the present, though perhaps windier and/or drier; (ii) an interval of decreased wind action, perhaps caused by greater humidity, that permitted stabilization of sand surfaces and modification of wind-fluted surfaces on soluble rock by solution and disintegration; and (iii) a recent shift to increased wind action, which was caused by reduced moisture and/or stronger winds. No evidence concerning the date of the earlier two episodes of contrasted eolian activity was found, but it is surmised that they date back not more than a few thousand years, perhaps much less. The current episode of renewed eolian activity is tentatively correlated with climatic conditions responsible for the recent marked recession of mountain glaciers, as reported by Broggi [in F. E. Matthes, *Trans. Am. Geophys. Union* **27**, 219 (1946)].

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26 May 1955

Prenatal Oxygen Deprivation and Subsequent Specific Behavior Dysfunctions

Recent experimentation (*1*) has indicated that unique anomalies follow physiological insults at specific points in the organism's development. Should the insults (irradiation, nutritional and oxygen deprivation, trauma, and so forth) occur at times when certain systems or tissues are undergoing the greatest differentiation and proliferation, these systems or tissues will show the most severe alteration in structure and function. If this is the case, two methodological uses may be suggested: (i) by properly timing the onset of the insult, information concerning the sequence of developmental events may be obtained; (ii) insults at prescribed periods may aid in describing the structure-function relationship that is inferred from the variations in the behavior of the organism.

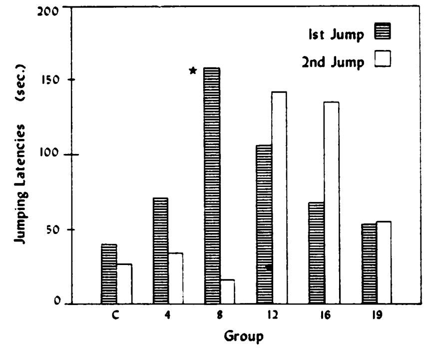

Fig. 1. The performances of the control and experimental groups on the first and second jumping tests. Plotted data are median scores. (The asterisk indicates that the difference between the experimental and control groups is significant beyond the 0.05 level.)

Our study (*2*) applies to this second approach for the purpose of clarifying the function of ablations when incurred in the young organism (chicks), that is, when the opportunities for experience are controlled. We propose that oxygen deprivation at the time of the greatest structural development of the visual-motor system [about 8 days, as indicated by the growth of the optic lobes and related structures (*3*)] would evince dysfunctions in visually dominant behavior.

Five incubation stages were used: 4, 8, 12, 16, and 19 days. Representing these conditions were 12, 17, 6, 12, and 15 chicks, respectively. Eighteen chicks served as controls. Subjects in the experimental groups were deprived of oxygen for the median lethal dose (LD_{50}) by immersion in distilled water at incubation temperature (99.5°F). The LD_{50} was a predetermined period of immersion ranging from 105 min for the 4-day group to 25 min for the 19-day group.

After the chicks hatched, the following measures were made: (i) weight (2nd day); (ii) sensitivity of the optokinetic reflex (7th day); and (iii) jumping performance (two measurements: 4th, 5th, or 6th day, and 11th, 12th, or 13th day, respectively).

An apparatus similar to the one designed by K. U. Smith (*4*) was used for measuring the optokinetic reflex. The drum, 22 in. in diameter, rotated at 4.3 rev/min. The vertical stripes were 2 in. wide. The index of reflex sensitivity was the time for 40 flexures of the head in response to the moving stripes.

A technique reported by Fletcher *et al.* (*5*) was used of measuring the chick's jumping behavior. The animal jumped from a platform 4 in. in diameter from heights starting at 15 in. and rising by 5-in. increments to 60 in. For each chick and for each height latency scores and the maximum height (that height for which the latency score was 360 sec or greater) were recorded. On each of the two jumping days, the subject was isolated from food and brood mates for 2 hr. The incentives for jumping were food and two brood mates.

Based on the developmental schedules of the embryo, we predicted that the 8-day incubation group would show: (i) a reliable difference in jumping behavior as indicated by latency scores; and (ii) inferior reflex sensitivity as indicated by greater time indices.

The graphic representations show the distinctiveness of the 8-day group. These subjects were significantly lower (*6*) ($p < .05$) than the controls at the first jumping test (Fig. 1). However, no reliable differences in performance were found at the second jumping test. The greatest difference (insignificant statistically) was between the control group and the 12-day groups.

On the optokinetic apparatus, only the 8-day groups could be statistically distinguished from the control group ($p < .01$; Fig. 2). No differences in weight were found between the control and experimental groups, nor were obvious anatomical or locomotor defects noted. Incomplete data on other tasks, such as the Fink Arrow Maze (*7*), suggest that the uniqueness of the 8-day group noted in this experiment need not apply to other behavior.

In conclusion, these performance data substantiate the predictions: Variations in visual-motor behavior were reliably affected when oxygen deprivation was incurred at the 8th day of incubation, the period of greatest development of the visual-motor system. Insignificant, but

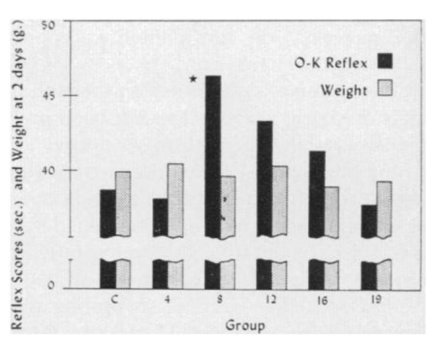

Fig. 2. Time scores on the opto-kinetic apparatus and weight measures on the 2nd day. Plotted data are median scores. (The asterisk indicates that the difference between the experimental and control groups is significant beyond the 0.01 level.)