milliliter was obtained from the National Bureau of Standards. The solution was prepared from a carbonate with a C^{14} ratio determined mass-spectrometrically at four different laboratories with results agreeing within 3 percent. Ten milliliters and 15 ml of this solution were added to 22.335 g and 23.148 g of Na_2CO_3, respectively, for conversion to C_2H_2. A third sample, serving as a blank, was prepared from the same carbonate without the addition of a spike. The results are listed in Table 2.

Assuming 5568 yr for the C^{14} half life (*5*), one obtains from the C^{14} ratio of $(1.238 \pm 0.03) \times 10^{-12}$ for standard wood carbon, a specific activity of 14.7 ± 0.4 disintegrations/min, which is in good agreement with the value of 15.3 ± 0.5 as determined by Anderson and Libby (*6*). The lower values reported by Hayes *et al.* (*7*) and by Fergusson (*8*) of 12.9 ± 0.2 and 12.5 ± 0.2 disintegrations/min, respectively, can be brought into agreement with the reported measurement only by assuming a correspondingly longer half life.

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1. Publication authorized by the director, U.S. Geological Survey. The assistance of Meyer Rubin in carrying out the measurements is greatly appreciated. Thanks are also due to Harmon Craig, not only for providing the necessary C^{13} analyses, but also for valuable discussions concerning the geochemistry of carbon isotopes. Corrinne Alexander carried out the technical procedure of sample preparation.
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7 June 1955

Sharks in Fresh Water

In a recent number of *Science* [**121**, 759 (27 May 1955)] is a note on the occurrence of sharks and sawfish in Lake Sentani, Dutch New Guinea. In it I read "How these salt-water fish became acclimated to fresh water in a lake 500 ft above set level is unknown."

There is no mystery about this at all. That certain species of sharks and rays, including sawfishes, enter fresh water freely and travel long distances into lakes and rivers has been known for a long time. It is now 75 years since I first read of the Ganges shark (*Carcharias gangeticus*) and its attacks on people bathing in the Hugli and Ganges rivers. Long ago A. B. Meyer, a celebrated German naturalist, recorded [*Nature* **13**, 167 (1875)] that sawfish (*Pristis microdon*) up to 20 ft in length were abundant in Laguna de Bay, Luzon. In 1870 Günther recorded this same sawfish in the Amazon and its tributaries, in the Zambezi below the great falls, and in the great rivers of Borneo and Sumatra.

For the past 35 years I have been familiar with the presence of sharks and sawfish in the rivers and lakes of the tropics. In the Philippines, the Ganges shark and the sawfish mentioned previously occur in all rivers of any size and in all fresh-water lakes where there is a good-sized outlet, unimpeded by a dam or waterfall, leading to the sea. They pass through rapids to reach the upper Agusan at least 150 mi from the sea by the winding river. I found the Papuans familiar with sawfish along the Sepik River, New Guinea, more than 300 mi from the sea; these fish undoubtedly go very far beyond that point. Far from being astonished at the presence of sharks and sawfish in Lake Sentani, I would be surprised if they did not occur there. There is no obstacle to the free passage of sharks and sawfish to and from Lake Sentani and the sea, especially in the rainy season. At that time several drainage systems become one vast sheet of water.

One must remember certain facts concerning fishes found in fresh water in the rainy tropics. First, an astonishing variety of marine fishes migrate up rivers and into lakes, many of them going to the remote interior as long as they are not stopped by waterfalls. Eels, mullet, and gobies may ascend in this way to elevations of 5000 ft. Second, in time of high water many rapids unsurmountable to migrating fishes during ordinary water stages become readily passable and are no longer a serious obstacle to them, no matter what Europeans or North Americans may think about it. Some kinds of these fishes remain but a short time, but most kinds remain until they are adult or nearly so and must return to the sea to breed.

The sharks and sawfishes mentioned do not breed in fresh water but, like many other marine fishes, find lacustrine life very attractive. The ecological conditions are very favorable to their existence and there is a great abundance of easily taken food, an altogether attractive situation. Unless cut off by huge permanent fish corrals, as at the outlet of Laguna Bombon, Luzon, sharks return to the sea to breed.

I have found that forest people, such as the Mandayas and Monobos in Mindanao, believe that the sharks they see in their rivers are females and that the sawfish are the males of the same fish. However this singular belief does not seem to be held by any people who are real fisherfolk, depending on fish for their main food supply.

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13 June 1955

Physiology of a Primary Chemoreceptor Unit

Progress in the physiology of chemoreception has been hampered by the fact that in most reported experiments the criteria of sensory excitation have been limited to behavioral responses of the animals studied. In some work on vertebrates (*1*), the responses of chemoreceptors have been approached somewhat more directly by recording afferent discharges in sensory nerve fibers that supply the receptor cells. However, these studies still leave in some doubt the nature of the response of the primary receptor surface to specific chemical stimuli.

Chemoreceptor cells of insects have special advantages for experimental work in this area of sensory physiology. These advantages include accessibility of the receptors, absence of a mucus coating over the receptor surface, the fact that the axon of the primary receptor serves as afferent fiber, and the unusually prominent development and sensitivity of the chemical senses of insects. Recent histological studies on single chemosensory hairs of insects have given new encouragement to the hitherto unsuccessful attempts to record electric activity associated with functions of the primary chemoreceptor cells of insects. Gabrowski and Dethier (*2*) found that the distal processes of two neurons extend to the tip of each tarsal chemosensory hair of the blowfly (*Phormia*), and similar observations have been made on the labellar chemosensory hairs of flies (*3*). Attempts to record electric changes in the region of the neurons at the base of the labellar sensory hairs met with some success (*4*), but the results were erratic owing to local shunting of potentials from the small fibers and unpredictability of electrode placement. The present method of recording potential changes between the small localized sensory surface on the tip of the chemosensory hair and the body of the animal has proved to be convenient and reproducible, and may have applications to other organisms and other sense organs.

A 15-mm length of 1-mm (outside

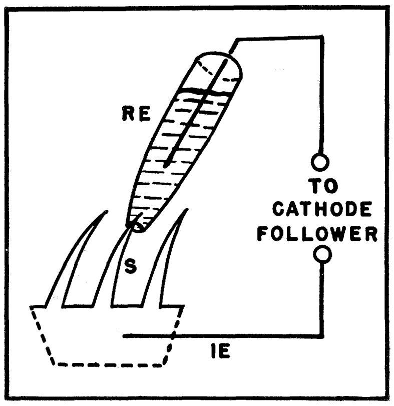

Fig. 1. Diagram of experimental preparation. *S,* chemosensory sensillum on labellum of fly; *RE,* recording electrode; *IE,* indifferent electrode.

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.

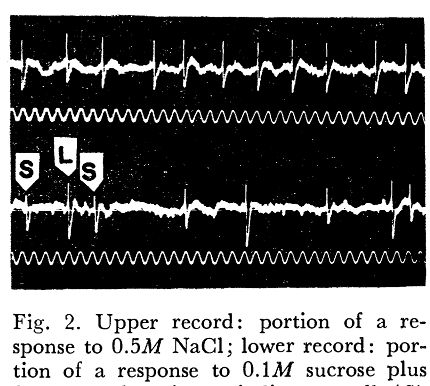

Fig. 2. Upper record: portion of a response to 0.5*M* NaCl; lower record: portion of a response to 0.1*M* sucrose plus 0.1*M* NaCl. Pointers indicate small (*S*) and large (*L*) spikes in the lower record. The time base in both records is 100 cy/sec.

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