principle has been established by us chiefly in the study of pulmonary collateral flow (*3*). The formula has made it possible to quantify observations of such flow made earlier by one of us (L. C.) at Yale University. Those investigations—the earliest in which this experimental design was applied to the study of a physiologic flow—have been extended in this laboratory to human subjects. In several instances we have measured total pulmonary collateral flow by this and an independent indirect method, with agreement between the two results. Our studies of shunt flows and of mitral regurgitation are in progress and are promising.

Since indicator dilution methods are not confined to cardiovascular physiology, it is conceivable that the principle here described will prove useful in other problems of flow measurement.

GILBERT E. LEVINSON*
LEON CUDKOWICZ†
WALTER H. ABELMANN‡
Thorndike Memorial Laboratory and
Second and Fourth (Harvard) Medical Services, Boston City Hospital, and
Harvard Medical School,
Cambridge, Massachusetts

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† Former research fellow, supported by a grant from the Massachusetts Heart Association. Present address: St. Thomas' Hospital, London, England.

‡ Established investigator, American Heart Association.

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Function of Giant Mauthner's Neurons in the Lungfish

Abstract. Unit spikes were recorded from the spinal cord of the lungfish *Protopterus* and were identified with Mauthner's axon. With these spikes occurred nongraded tail flips suggesting startle responses. The tail flip and the giant spike resulted from certain forms of jarring and prodding. The conduction velocity for the slightly myelinated 45 μ diameter fibers was 18.5 m/sec.

The Mauthner's neurons of teleosts and urodeles have been the subject of many anatomical and embryological studies (*1*). Speculations about their function have had little physiological basis, and electrical recordings presumably from these neurons (*2–4*) have shed no real light on their normal role in the animal. Berkowitz (*4*) was the first to give some experimental grounds for assuming a special startle-response function in a carp, *Cyprinus,* and Retzlaff (*5*) reported comparable results which could be similarly interpreted. Berkowitz showed that physiological (tapping) stimulation of a certain type elicited sharp tail flips and high-velocity cord potentials, and that electrical stimulation of the cord just at the threshold point for such post potentials gave the same tail flip. The potentials were not all-or-none but presumably involved both Mauthner's and some other large fibers of the medial longitudinal fasciculus. Retzlaff recorded from what was doubtless the Mauthner's cell and saw similar tail jerks, but his results, obtained with semimicroelectrodes, do not permit the conclusion that the response is all-or-none activity in a single unit, though the Mauthner's spike and tail jerk were one-to-one. It seemed desirable to show more clearly whether a stereotyped, abrupt, maximal, twitchlike, normal movement is mediated by activity of the Mauthner's axon alone.

That *Protopterus* would be especially suitable for such experiments was suggested when Smith (*6*) called attention to the large size of the Mauthner's axons in this lungfish. In *Protopterus* this pair of fibers in the ventral columns of the spinal cord is truly giant and, therefore, may be expected to be accessible to selective electrical stimulation by virtue of a relatively low threshold and to single-fiber recording from the intact cord. The experiments described in this report (*7*) were performed on three 20- to 30-cm fish.

On the assumption that giant fibers mediate startle responses, attempts were made with various types of stimulation to produce sudden, single, stereotyped, large-magnitude movements. Individuals varied considerably in their responsiveness, but, although they were usually sluggish, all of them under some kinds of stimulation showed this type of reaction, confined to a sharp flexion of the tail. The response was produced by deep probing with a needle, by dropping the dish containing an animal onto the table, and by massive electrical stimulation of the body surface or of the exposed spinal cord. It occurred more readily in one specimen when the fish was placed on a dry surface. It was sometimes repetitive, alternating from side to side (compare Retzlaff's simultaneous stimulation of both VIIIth nerves). Weak vibration from a tuning fork, a jarring of the aquarium, strong light, or disturbances of spatial orientation failed to elicit the response.

Application of single electrical shocks to the dorsal surface of the spinal cord, above a sharp threshold, caused the same type of movement. The magnitude of the response to a single shock was nearly as great as that resulting from tetanizing frequencies. Electrical recordings from a second region of the cord showed two main components of activity following electrical stimulation. The first was a single all-or-none, sharp-threshold spike having an apparent conduction velocity of 18.5 m/sec (at about 20°C). The second was a complex wave which was graded in magnitude with respect to stimulus intensity and which was conducted at apparent velocities of between 4.1 and 1.3 m/sec. Spikes similar in form to the first wave were seen also during stimulation of the body surface by the same probing and electrical shock which had been found to give the startle response. These spikes were many times larger than any which occurred during ordinary locomotion and were always accompanied by the flip of the posterior trunk and tail described above.

The results indicate that the Mauthner's neuron in the lungfish, by itself, can mediate a special type of prompt, nongraded tail-flip response which may be compared with the startle response of many invertebrates possessing giant fibers (*8*).

The velocity of 18.5 m/sec is surprisingly low in comparison with the 35- to 40-m/sec velocity at 5°C (*5*) and the 50- to 60-m/sec velocity at 10° to 15°C (*2*) in *Ameiurus*—a fish in which Mauthner's fibers measure 22 to 43 μ in outside diameter—and with 80 m/sec (at 23°C) in *Parasilurus* (*3*) and 55 to 63 m/sec (at 20° to 25°C) in *Cyprinus* —fish in which Mauthner's fibers measure 55 to 65 μ (*4*). Random sections through the cord in the same specimens of *Protopterus* showed Mauthner's fibers of 45 μ in formalin-fixed preparations. These fibers had myelin sheaths accounting for no more than 3 percent of the total diameter, as compared with 50 percent in *Ameiurus* (*2*). There can be little doubt that the fiber stimulated and recorded from is Mauthner's, in view of the great discontinuity in size between it and the next largest fibers—a feature in which *Protopterus* stands out.

The large number of input sources to this cell which have been histologically identified appear to result in the simplest of outputs—one or a few impulses, or nothing. The most conspicuous source of input is vestibular, but simple displacement, tilting, or acceleration are apparently inadequate to fire the cell. The only physiological form of adequate stimulation found in these specimens, under the conditions of these experiments, was a severe jar. Possibly this represents an intense and synchronous activation of certain elements of the VIIIth nerve, similar to Retzlaff's electrical stimulation of the same nerve. By analogy with carp, earthworm, crayfish, and squid, it may be expected that under other conditions of set or readiness a much weaker stimulus would be adequate. It seems likely that much of the input is integrated in such a way as to determine the probability of firing by certain limited sources or temporal patterns of impulses. Furthermore, the ratio of input to output impulses is probably very high and therefore insensitive to considerable fluctuations in absolute numbers of input impulses of the most active pathways.

DONALD M. WILSON*
Department of Zoology,
University of California, Los Angeles

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Thermal Decomposition of Rare Earth Fluoride Hydrates

Abstract. A thermogravimetric study of the thermal decomposition of La, Nd, Sm, Gd, Dy, Er, and Y fluoride hydrates shows that minimum dehydration temperatures are from 315° to 405°C; conversion of the fluorides to oxyfluorides begins in the 600° to 690°C temperature range.

As part of our investigations of the thermal decomposition of rare earth compounds (*1*), the pyrolysis of the rare earth fluoride hydrates was studied. The dehydration of these compounds is of interest at the present time because the anhydrous fluorides are used to prepare the rare earth metals.

Popov and Knudsen (*2*) previously studied the isothermal decomposition of the anhydrous rare earth fluorides and found that the pyrolysis took place in two steps. The first step was the conversion to the metal oxyfluoride; this was followed by the second step, the conversion of the oxyfluoride to the metal oxide. To our knowledge, the dehydration of the hydrated metal fluorides has not been described, and it is the subject of this report.

The rare earth fluorides were prepared by precipitation of the metal ions with aqueous hydrogen fluoride. The precipitated metal fluorides were filtered off through filter paper, washed with water, and air-dried for 24 hours at room temperature. Under these conditions, the metal fluorides corresponded approximately to the ½- or 1- forms of the hydrates.

An automatic recording thermobalance, previously described (*3*), was used to obtain the thermolysis curves. The samples ranged in weight from 90 to 100 mg and were run in duplicate or triplicate. A furnace heating rate of 5.4°C per minute was employed.

The thermograms of the rare earth fluoride hydrates are given in Fig. 1. From these curves and from previous studies (*2*), the following general pyrolysis pattern is presumed to take place:

$$MF_3\cdot(\tfrac{1}{2}\text{ or }1)H_2O \rightarrow MF_3 \rightarrow MOF$$

All of the compounds began to evolve water of hydration in the 40° to 60°C temperature range. However, horizontal weight levels corresponding to those of the anhydrous metal fluorides were obtained only for neodymium, samarium, and gadolinium. All of the other metal fluorides lost weight continuously throughout the entire thermogram.

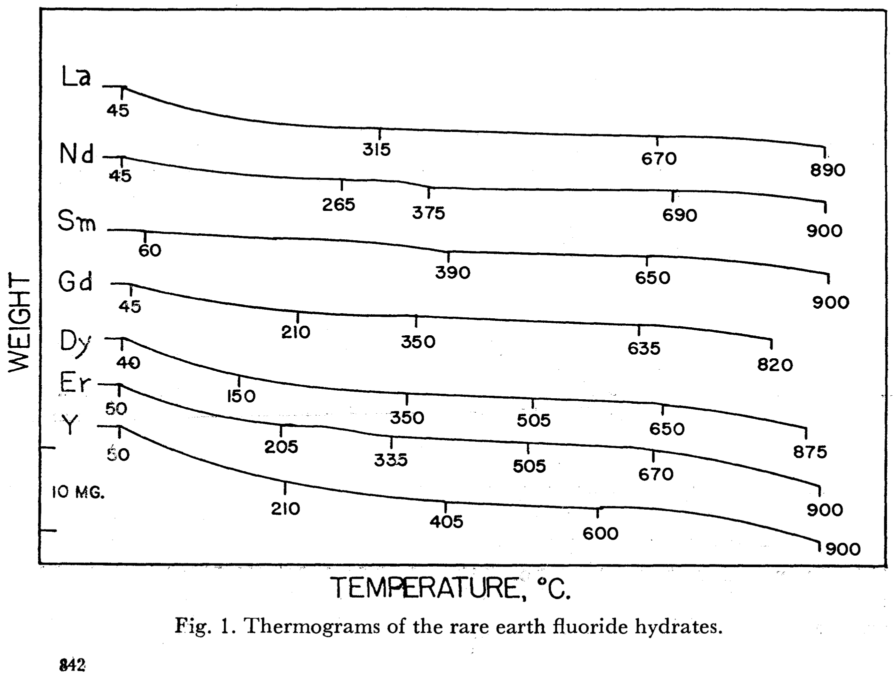

Fig. 1. Thermograms of the rare earth fluoride hydrates.

The pyrolysis of the metal fluorides to the oxyfluorides began in the 600° to 690°C temperature range. The rates of pyrolysis were quite slow and did not result in the metal oxyfluoride weight levels even at 900°C. Since the upper limit of the thermobalance furnace is 900°C, the pyrolysis could not be extended to higher temperatures.

WESLEY W. WENDLANDT
Department of Chemistry
and Chemical Engineering,
Texas Technological College, Lubbock
BERNARD LOVE
Research Chemicals, Incorporated,
Burbank, California

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Transient Memory in Albino Rats

Abstract. Rats were trained on the repeated reversal of a position habit in a T-maze. Test trials of memory were given at varying intervals after the completion of each reversal. Those animals exhibiting a consistent preference for one side failed to retain the effects of training to the nonpreferred side for more than a few minutes.

Boycott and Young (*1*) have demonstrated the possible existence of reverberatory circuits mediating a discrimination habit in brain-damaged octopuses. The animals were preoperatively trained to attack a crab but to withhold the attacking response when the crab was presented along with a white card. If a response was made to the latter condition, the octopus was punished with an electric shock. Damage to certain parts of the brain eliminated the habit. The octopus attacked the crab under both conditions when trials were spaced by 2 or more hours. If, however, one negative trial (white card presentation) succeeded another within 5 minutes, the animal, correctly, withheld the response. Apparently the preceding negative trial had set up some short-term activity within a neural system corresponding to a memory trace of that trial which accounted for the absence of a response to the crab a few minutes later. The subsidence of this neural activity would explain the reappearance of the attacking response after an interval of 2 hours.

The present experiment reveals a similar transient memory in albino rats, but under a different set of conditions. Normal rats and rats subjected to either cortical or subcortical damage were trained on a simple water T-maze. Prior