tivation falls from 71 to 42 percent; with double the concentration of catechol, only 15 percent of the epinephrine is inactivated (Table 1). Neither ATP nor catechol interferes with chemical titration; ATP interferes with biological titration only at high doses. Biological tests have confirmed the results obtained with the fluorescence method.

Many plant phenolics with a catechol nucleus sensitize smooth muscle to epinephrine (*4*); inhibition of methyltransferase is probably the responsible mechanism.

The facts (i) that, in vivo, iproniazid or any inhibitor of amino oxidase does not sensitize to epinephrine or adrenergic nerve stimulation and (ii) that inhibitors of O-methyltransferase do sensitize in vivo are powerful arguments in favor of the opinion that methyltransferase (and not amino oxidase) is the enzyme which normally inactivates the bulk of catecholamines in mammals (see *5*).

ZENON M. BACQ, LUC GOSSELIN,
ALBERT DRESSE, JEAN RENSON
Department of General Pathology and
Institute of Physiology,
University of Liège, Belgium

References and Notes

1. Z. M. Bacq, *Arch. intern. physiol.* 42, 340 (1936); 44, 15 (1936).
2. J. Axelrod and R. Tomchick, *J. Biol. Chem.* 233, 702 (1958); E. H. LaBrosse, J. Axelrod, S. S. Kety, *Science* 128, 593 (1958).
3. U. S. von Euler, *Noradrenaline* (Thomas, Springfield, Ill., 1956).
4. *The Pharmacology of Plant Phenolics* (Proceedings of a symposium held at Oxford, April 1958), J. W. Fairbairn, Ed. (Academic Press, New York, 1959). Of particular interest are the contributions of E. C. Batesmith (p. 133) and of J. Lavollay and J. Neumann (p. 103).
5. Z. M. Bacq, *Pharmacol. Revs.* 1, 1 (1949).

5 June 1959

Prolactin, a Factor in Promoting Survival of Hypophysectomized Killifish in Fresh Water

Abstract. The naturally occurring corticosteroids, cortisol and aldosterone, failed to promote survival of hypophysectomized *Fundulus heteroclitus* in fresh water. Extracts of *Fundulus* interrenal tissue, carp corpuscles of Stannius, and hog renin were ineffective. Injection of whole rat-pituitary brei was partially successful. Highly purified prolactin maintained survival, although the recipients did not eat normally. A synergic action of prolactin with some unidentified pituitary hormone is suspected.

Burden (*1*) showed that the hypophysectomized and normally euryhaline killifish, *Fundulus heteroclitus,* is unable to survive in fresh water. Death results from progressive asthenia, correlated with hypochloremia, which becomes severe after 6 to 7 days at 15° to 17°C. Replacement therapy with *Fundulus* pituitary brei was completely successful; perch pituitary was partially effective, but pollack pituitary gave negative results. Mammalian pituitary hormones (TSH, ACTH GH, and posterior lobe powder) were ineffective. Lack of participation of the thyroid was confirmed by administration of thyroxin. More recently, Harris (*2*) found that hypothyroidism, resulting from treatment with I^{131}, had no detrimental effect on the survival or blood chloride levels of this species in fresh water. Burden suggested that a special agent, regulating adaptation to fresh water, was present in the pituitary of teleosts living in this medium.

In Burden's experiments lack of participation of the adrenal, indicated by failure of natural stimulation with exogenous ACTH, was partially confirmed by negative results with DOCA. Recent studies by one of us (*3*) showed that the circulating glucocorticoid of *Fundulus* is cortisol. Moreover, incubation of the head kidney, containing the adrenocortical (interrenal) tissue, with tritiated progesterone results in the synthesis not only of cortisol but also of other steroids, including aldosterone (*4*). An investigation was therefore undertaken to study the possible participation of these natural steroids in the survival of killifish in fresh water.

Hypophysectomized fish, pretested for failure to withstand fresh water, were rescued at the onset of severe symptoms and allowed to recover in salt water. Each experimental group contained four such fish. Hormones or extracts dissolved in 0.6-percent NaCl were administered by intraperitoneal injection on alternate days, at constant volume (0.01 ml/g wt. of fish). The temperature was 15° to 16°C except at the higher dose of cortisol, which was tested at 20°C. It was noted that failure in fresh water is accelerated at the higher temperature. Negative results were obtained with cortisol (2.5 and 0.0025 μg/g wt.), aldosterone (24 and 2.4 μμg/wt.) and extracts of right and left head kidney of *Fundulus* [20 mg (wet wt.)/g wt.] The lower doses of cortisol and aldosterone were considered to be at physiological levels. The right head kidney contains the major part of the adrenal tissue in this species (*5*).

These results, and those of Burden, indicate that the adrenal plays no direct role in regulating survival of *Fundulus* in fresh water. This is in accordance with recent work of Holmes (*6*), who found that in rainbow trout cortical steroids promoted renal salt retention, under a salt load, but that this effect was offset by an enhanced loss of salt through the gills and inhibited re-uptake. Different results have been reported, however, for the goldfish (*7*).

Other hormones that might be concerned with teleostean osmoregulation were considered. The gonadotropins and sex steroids can presumably be excluded, since fish of either sex, juvenile, mature, or in seasonal regression, can move freely from salt to fresh water. On the other hand, the corpuscles of Stannius may play some role in osmoregulation (*8*), although there is no evidence that these glands are regulated by the pituitary (*5*); however, a brei of carp corpuscles of Stannius [1 mg (wet wt.)/g wt.] gave negative results. Renin, said to be present in the kidneys of fresh-water but not in those of marine teleosts (*9*), was tested at two dosages (50 μg/g wt. on alternate days; 5 μg/g wt. daily) without beneficial action.

The possible participation of an unidentified mammalian hypophysial hormone was tested with whole rat-pituitary brei [1 mg (wet wt.)/g wt.]: two fish out of four survived for 20 days but refused to eat, and neither recovered in salt water.

Prolactin, which is known to be present in the teleostean hypophysis (*10*) and which initiates the "water drive" in efts of *Triturus* (*11*), was tested (10 μg/g wt.) with unexpectedly successful results. All four recipients survived for 20 days and remained lively, although they ate little. A combination of prolactin with some other pituitary hormone may be necessary for complete adaptation to fresh water, and investigations of this aspect of the problem are in progress. The synergic action of prolactin is well known in mammalian endocrinology, and its function in potentiating the melanophore-proliferating effect of intermedin in *Fundulus* has been established (*12*). The ineffectiveness of pollack pituitary brei, reported by Burden, may be correlated with the low prolactin content of this material (*10*). Rat pituitary, on the other hand, evidently, contains sufficient prolactin to be partially effective (*13*).

GRACE E. PICKFORD
JOHN G. PHILLIPS*
Bingham Oceanographic Laboratory,
Yale University,
New Haven, Connecticut

References and Notes

1. C. E. Burden, *Biol. Bull.* 110, 8 (1956).
2. P. J. Harris, thesis, Yale University (1958).
3. J. G. Phillips, in I. C. Jones, *et al., Comparative Endocrinology* (Wiley, New York, in press).
4. ——— and P. J. Mulrow, unpublished.
5. G. E. Pickford, *Bull. Bingham Oceanog. Coll.* 14, 5 (1953).
6. W. N. Holmes, in I. C. Jones *et al., Comparative Endocrinology* (Wiley, New York, in press).
7. A. W. Sexton, thesis, University of Missouri (1955).
8. P. Rasquin, *Biol. Bull.* 111, 399 (1956).
9. M. Friedman and A. Kaplan, *J. Exptl. Med.* 75, 127 (1942); ——— and E. Williams, *Proc. Soc. Exptl. Biol. Med.* 50, 199 (1942).
10. W. C. Grant, Jr., and G. E. Pickford, *Biol. Bull.,* in press.

11. W. C. Grant, Jr., and J. A. Grant, *ibid.* **114**, 1 (1958).
12. G. E. Pickford and B. Kosto, *Endocrinology* **61**, 177 (1957).
13. This investigation was supported by a grant from the National Science Foundation (NSF G-4001). We should like to thank the following for donating hormones used in this study: A. A. Renzi (aldosterone); Choh Hao Li (highly purified prolactin); and Irvine H. Page [hog renin (assay: 10 mg caused a rise of 100 mm of Hg in the dog)].
* Fellow of the Commonwealth Fund of New York. Present address: Department of Zoology, Sheffield University, England.

20 March 1959

Differentiation of Activity of Three Mouse Strains with Magnetic Pickup Apparatus

Abstract. An activity pickup, when used with a high-gain amplifier, permits records to be made of essentially all the activity of a mouse. The sensitivity is such that the differences in the activity patterns of strains of mice can be determined.

When the activity of small animals is appraised, the animal is usually required to cause movement of a relatively large mass, most commonly a pan or an entire cage, which is then connected to a recording device of some sort (*1*). Problems frequently encountered in such apparatus are incomplete recording of activity, artifacts due to resonance, and feedback to the animal due to pan or cage inertia and noise in the recording apparatus.

The apparatus described in this report (*2*) apparently circumvents all these difficulties. The activity pickup employs the principle of movements of a small iron plate which induces electric current in a coil with a bar magnet core. The currents thus produced are amplified electronically and recorded as activity.

Figure 1 shows the apparatus schematically. Movements of the mouse or other small animal cause micromovements of the galvanized iron plate *A*. Magnetic lines of force flowing between the poles of the magnet *NS* are altered by the movement of the plate, and thus current proportional to the movement is induced in the windings; the current is fed (*C*) to a preamplifier, amplifier, and recorder. Specifications are as follows: *A*, galvanized iron plate, 22 gauge, 3 by 4 in.; *B*, latex tubing, ½ in., ¼ in. I.D., cemented to the plate by rubber-to-metal cement. *NS*, 3-in. bar magnet wound with one layer of magnet wire. The specifications are for a mouse apparatus; with slight changes the apparatus could be adapted to larger or smaller animals. A Grass EEG machine was used for amplification and recording.

The plate is doubly damped, by the latex tubing and the attraction of the magnet, and resonance is kept to a minimum without friction. Use of larger plates tended to cause resonance. Three such plates were used, the leads being connected in parallel. For multiple-plate recording, adjacent magnets should be arranged with like polarity (or repulsion) for maximum sensitivity. Clear plastic walls of dimensions that allow 1/16-in. clearance of the plates act as the cage and permit observation of the mouse. All exposed wire is covered with rubber tubing to protect it from urine. The plate is built up to allow ½-in. clearance between the magnet and the plate. The apparatus is mounted on firmly damped ¼-in. mesh screening material.

Sensitivity is such that virtually all activity can be recorded, from shaking and trembling to running and jumping. Artifacts appear to be minimal or absent. On the records obtained, activity resolves into three major components: (i) large discrete deflections, correlated with jumping, jerking, and sudden movements in general; (ii) moderate, continuous deflections, correlated with walking, shaking, trembling, and scratching; (iii) quiet periods.

Figure 2 shows representative records of three mouse strains. Ten male mice were tested in each strain, and the activity patterns illustrated are characteristic for the given strains. The top record is of *Peromyscus gracilis*, a wild mouse exhibiting much running and jumping behavior. The middle line shows activity of strain C57BL/6, an aggressive, fighting mouse, which is characterized by many sudden movements with a moderate amount of continuous activity. Strain A/JAX, a standard laboratory albino, shows less activity of all kinds than the other two strains.

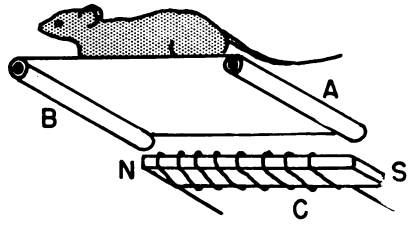

Fig. 1. Schematic representation of pickup apparatus.

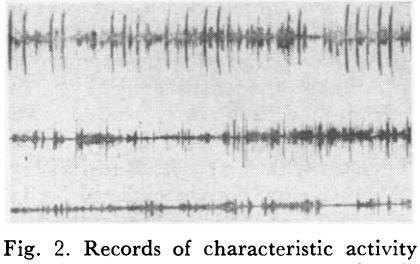

Fig. 2. Records of characteristic activity patterns of three different strains of male mice: (top) *Peromyscus gracilis*; (middle) C57BL/6; (bottom) A/JAX.

The sensitivity of the activity pickup apparatus described suggests possible application in psychopharmacological studies.

WALTER G. MITCHELL*
Hamilton Station, Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Maine

References and Notes

1. C. C. Stewart, *Am. J. Physiol.* 1, 40 (1898); J. S. Szymanski, *Arch. ges. Physiol. Pflüger's* 158, 343 (1914); K. M. Wilbur, *Science* **84**, 274 (1936); C. P. Richter, *Quart. Rev. Biol.* 2, 307 (1927); ——— and G. H. Wang, *J. Lab. Clin. Med.* 12, 289 (1926); B. F. Skinner, *J. Gen. Psychol.* 6, 3 (1933); J. M. Hunt and F. Marcuse, *Am. J. Psychol.* 52, 616 (1939); T. Word and J. A. Stern, *J. Exptl. Anal. Behavior* 1, 200 (1958).
2. I was a National Science Foundation postdoctoral fellow when this work was carried out. The assistance and cooperation of John L. Fuller and John King are gratefully acknowledged.
* Present address: Box 281, Crozet, Va.

2 April 1959

Tartaric Acid Metabolism of Neurospora crassa

Abstract. The growth of wild type *Neurospora crassa* is stimulated by various organic acids including tartaric, tartronic, and mesoxalic acids. Evidence is presented that this organism converts *d*- or *l*-tartaric acid to tartronic and mesoxalic acid, probably by fixation of CO_2.

The function of tartaric acid has been a biochemical enigma since Pasteur initiated research on this substance. Recently its metabolism by several organisms or tissues has been reported with varying results. Cleland and Johnson (*1*) find that it is converted quantitatively to oxalate by *Aspergillus niger*. Nomura and Sakaguchi (*2*) find that the principal product is succinate with *Pseudomonas incognita*, while Kun and Hernandez (*3*) propose that, with animal mitochondria, the first product is oxaloglycolic acid which can then be converted to a number of products, including diketosuccinic acid and glyoxylic acid. When, therefore, we found that *Neurospora crassa* is stimulated by tartrate as well as by several other organic acids, we made an effort to determine the mechanism of this stimulation and the fate of the tartrate.

Conidia were taken from cultures of *Neurospora crassa*, strain 74A (wild type), grown on minimal medium (*4*) with 2 percent (wt./vol.) sucrose and 1.5 percent (wt./vol.) agar. Aliquots were inoculated into 20-ml portions of Westergaard-Mitchell medium (*5*) containing 2 percent (wt./vol.) sucrose and supplements. Pads were harvested after 72 hours, dried, and weighed.

Among the organic acids which were