

## 13660

## Heat Narcosis of Brain and of Striated Muscle of the Frog.

SERGEI FEITELBERG\* AND ERNEST P. PICK.†

*From the Laboratories of the Mount Sinai Hospital, New York City.*

Claude Bernard observed that frogs that had been immersed in water of 37 to 38°C lost their reflexes and became completely paralyzed. After cooling, they regain their motility. Because of the reversible central paralysis in this experiment, Meyer<sup>1</sup> referred to it as "heat narcosis" and attributed it to changes in the lipoids, similar to those ascribed to other forms of narcosis. The widespread occurrence of lipoids in all cells of the body could, according to Meyer, satisfactorily account for paralysis of tissues other than those of the nervous system.

I. *The effect of heat on striated muscle.* The effects of heat have been demonstrated on the conduction system of the frog heart (Amsler and Pick,<sup>2</sup> Clark<sup>3</sup>), on the sciatic nerve of the frog (Bremer and Titeca<sup>4</sup>), and on the smooth muscle of the guinea pig uterus (Evans<sup>5</sup>). Because of the apparent generalized paralysis of frogs immersed in hot water, we have chosen to investigate skeletal muscle itself. The muscles of the left hind limb (*Rana esculenta*) were prepared for the experiment by section of the nerve trunks to this extremity as they left the vertebral canal. There was an interval of 3 weeks between the time of the nerve section and the experiment. After this period degeneration of the nerves is complete.

Such prepared frogs were immersed in water of 38 to 40°C for a period of 5 to 10 minutes, after which they were removed. This immersion produced heat paralysis. Electrodes were then inserted into the gastrocnemius muscle of the denervated extremity. A 60 cycle sinusoidal alternating current was used for stimulation. The magnitude of the threshold stimulus necessary to produce a twitch was determined every 2 to 3 minutes. It was found that the threshold

---

\* Aided by a grant from the Dazian Foundation for Medical Research.

† Aided by a grant for apparatus by the Ella Sachs Plotz Foundation.

<sup>1</sup> Meyer, H. H., "Waermenarkose," in *Experimentelle Pharmakologie*, by H. H. Meyer, R. Gottlieb, and E. P. Pick, 1936, Berlin and Vienna, 154.

<sup>2</sup> Amsler, C., and Pick, E. P., *Arch. f. Exp. Path. und Pharm.*, 1918, **84**, 234.

<sup>3</sup> Clark, A. J., *J. Physiol.*, 1920-1921, **54**, 275.

<sup>4</sup> Bremer, F., and Titeca, J., *Compt. rend. des séances de la Société de Biologie, Soc. Belge de Biol.*, 1933, **115**, 413, and 1934, **118**, 371.

<sup>5</sup> Evans, C. L., *J. Physiol.*, 1921, **54**, 139 (proceedings).

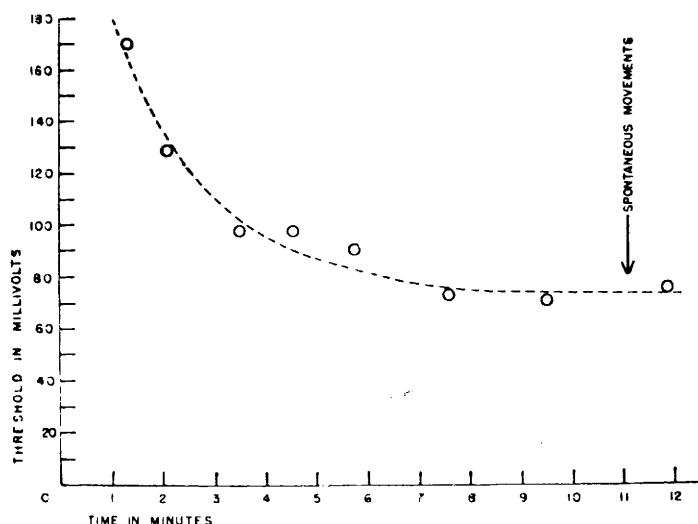


FIG. 1.

Threshold of the denervated gastrocnemius of the frog, after immersion for 10 min. in water of 39°C.

is highest immediately after removal of the frog from the warm bath, drops rapidly in the first few minutes and gradually returns to normal as the animal approaches room temperature. The normal threshold is usually reached before spontaneous muscular movements appear in the intact limbs. Fig. 1 illustrates this experiment.

II. *Effect of heat on the brain (heat narcosis).* Heretofore it has not been possible to demonstrate cerebral heat narcosis by direct qualitative and quantitative method. We have attempted to do this by means of electroencephalography.

Frogs were immersed in a water bath of 38 to 40°C for a period of 10 minutes. This produced complete paralysis. After removing the animals from the water bath three Hoagland electrodes were placed into the skull<sup>6</sup> and the electroencephalogram recorded continuously until the frogs regained spontaneous muscular activity (Fig. 2). At first, while the frog is completely paralyzed, the amplitudes of the electrical brain waves are very low, as in deep narcosis (1 min.). After a while short bursts of fast alpha waves (15 to 20 per second) appear (7 min.), and these bursts gradually become more prolonged and occur more often (10 min.) until they merge into a continuous pattern corresponding to the electroencephalogram of a normal frog (14 min.). The frog recovers from his paralysis at this time. A similar series of events is observed following ether narcosis (Fig. 2).

<sup>6</sup> Feitelberg, S., and Pick, E. P., *PROC. SOC. EXP. BIOL. AND MED.*, 1942, **49**, 654.

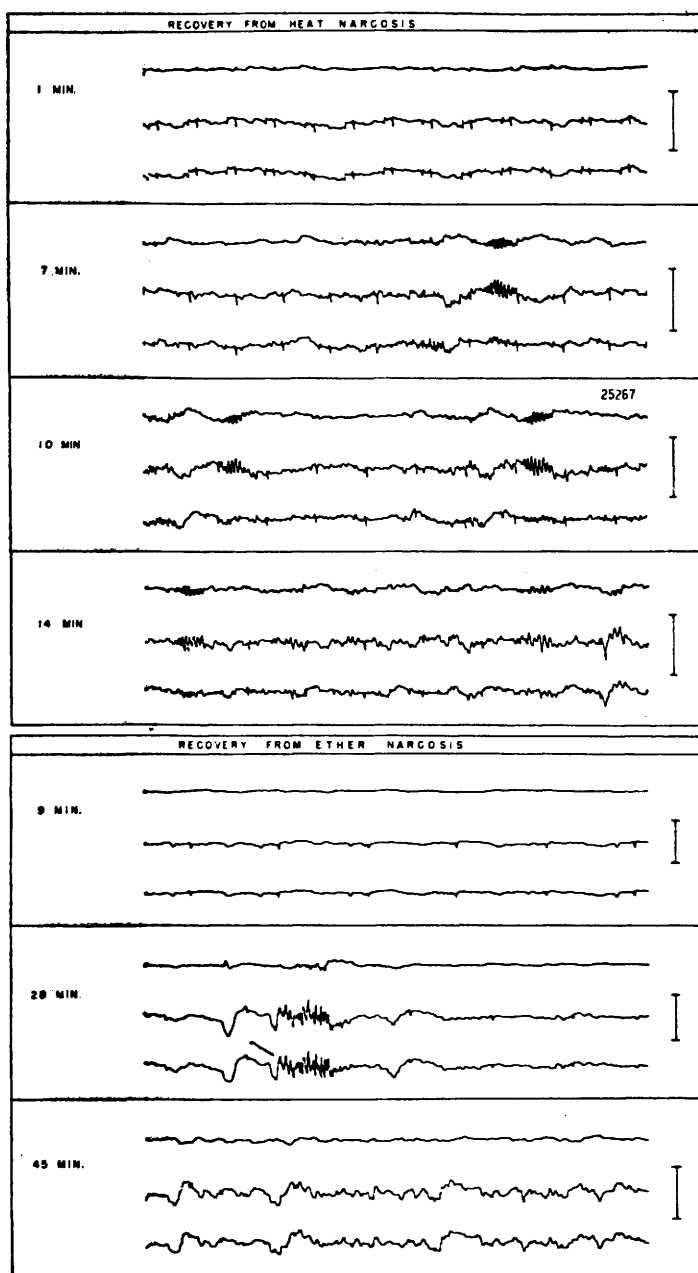


FIG. 2.

Electroencephalograms (frog) during recovery from heat and ether narcosis. Length of each record—8 sec. Marks at right = 100 microvolt. Notations at left indicate time after removal from water ( $40^{\circ}\text{C}$ , immersion for 10 min.) and after removal of ether, respectively.

It appears that the respiratory center is the first to recover, since the alpha bursts described above coincide with the slight, but distinct respiratory movements which are the first manifestations of the return of muscular activity.

Heat narcosis as demonstrated by the electroencephalogram can also be produced by immersion in water of 33 to 35°C, although the frogs have to be immersed for a longer period of time (15 to 20 minutes) and the recovery is more rapid.

*Conclusion.* The effects of immersion of frogs in water of 38 to 40°C on the threshold of denervated skeletal muscle and on the electrical activity of the brain have been investigated. (1) The muscular threshold to electrical stimulation is increased, and returns to normal after 5 to 10 minutes. (2) The brain waves disappear almost completely. After several minutes fast alpha activity appears in single bursts, which occur more often. After 10 to 15 minutes the normal brain pattern returns. (3) The effects on the muscle and on the brain do not appear to be related with each other since the muscular threshold returns to normal before the appearance of a normal electroencephalogram.

The present experiments demonstrate for the first time that the brain is subject to a reversible heat paralysis as other organs.

### 13661 P

#### Lobule-Alveolar Growth of Mammary Glands of Hypophysectomized Female Rats.

RALPH P. REECE AND SAMUEL L. LEONARD.

*From the Department of Dairy Husbandry, New Jersey Agricultural Experiment Station,\* New Brunswick, N.J., and Department of Zoology, Cornell University, Ithaca, N.Y.*

In previous experiments we<sup>1</sup> have observed that the simultaneous administration of estrogen and growth hormone induced typical estrogen stimulation of the mammary glands of hypophysectomized male rats. In addition it has been shown that the injection of testosterone into sexually mature spayed rats stimulated growth of the lobule-alveolar system of the mammary glands<sup>2</sup> and furthermore

\* Journal Series Paper of the New Jersey Agricultural Experiment Station, Rutgers University, Department of Dairy Husbandry.

<sup>1</sup> Reece, R. P., and Leonard, S. L., *Endocrinology*, 1941, **29**, 297.

<sup>2</sup> Reece, R. P., and Mixner, J. P., *Proc. Soc. Exp. Biol. and Med.*, 1939, **40**, 66.