of the left phrenic nerve may be associated with the mechanical elevation of the stomach, which leads to dumping of the food into the duodenum. Surprisingly, a similar rapidity of gastric emptying is seen in the dog, which does not assume the up-right position of the human. After phrenicotomy the stomach in the dog was ballooned, and hypotonia and hypokinesia were apparent, but there was never any vomiting. The small intestine appeared moderately contracted, with puddling of barium. Although a relatively large gas bubble was present in the fundus of the stomach after phrenicotomy, no or very little gas appeared in the intestine.

Following bilateral supradiaphragmatic vagotomy, there was much gas in the stomach and intestines and severe vomiting of frothy mucoid material was present, and the dogs appeared to be quite ill.

When the left phrenic nerve and both vagi were cut at the same time, there was no vomiting and the animals did not appear to be ill at any time postoperatively.

While left side phrenicotomy, performed in addition to bilateral vagotomy, does not relieve the retention and loss of tone of the stomach which follows bilateral supradiaphragmatic vagotomy only, yet, a number of disturbing complications of vagotomy such as gaseous distention and vomiting were not observed. It is possible that in case of atony of the stomach the pumping action of the left diaphragm forces air into the stomach, which cannot escape through the cardia, and part of which enters the intestine. Achalasia of the cardia may be present following supradiaphragmatic vagotomy and may be a factor in the retention of air in the stomach. Paralysis of the left diaphragm by phrenicotomy may abolish the pumping of air into the stomach and, by stretching the stomach forward, may facilitate escape of air through the esophagus.

Discrepancies in the clinical reports on gastro-intestinal effects of interruption of the left phrenic nerve may be due in part to the fact that the patients were suffering from advanced tuberculosis of the lungs, possibly also from intestinal tuberculosis. Furthermore, the method of interruption of the phrenic nerve is important, whether it was crushed, cut, or avulsed. In cases of avulsion or exeresis in the neck, sympathetic fibers may have been disturbed, thereby accounting for additional symptoms.

We do not propose left side phrenicotomy in cases of gastric atony and retention, but merely want to bring to attention some of the relations between the diaphragm and the gastro-intestinal system.

*Summary.* Section of the left phrenic nerve is followed by gastric hypotonia and hypokinesia and the presence of a large gas bubble in the fundus of the stomach. Gastric emptying time is shortened considerably. The barium appears to puddle in a moderately contracted intestine. There were no symptoms observed which could be associated with the so-called gastro-cardiac symptom complex. When phrenicotomy is done simultaneously with vagotomy, the vomiting and the gaseous distention of the gastro-intestional tract associated with bilateral supradiaphragmatic vagotomy only, are not seen.

## 16425 P

## Relation Between Resting and Action Potential in the Frog Eye.*

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It has been observed that the magnitude (b-wave) of the action potential elicited from the excised frog eyeball in response to a light stimulus varies with the magnitude of the resting potential,[1] other conditions remaining

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[1] Therman, P. O., *Acta Societatis Fennicae, N.S.B.*, 1938, **2**, No. 1.

constant. It has further been reported[2] that the above direct relation was consistently observed in the dark-adapted eyes of intact curarized frogs.

These observations imply that the sensitivity of the retina, measured by the retinal electric response to a constant intensity, constant duration light stimulus, is determined by the resting potential as well as by the state of adaptation.[3] The theoretical importance of this implication indicates the necessity for quantitative data.

*Method.* Experiments were performed on two types of frog eye preparations: (1) excised but intact eyeballs of frogs (*Rana pipiens*) and (2) excised enucleated eyeballs. Electrical contact with the eyes was made through agar impregnated wick electrodes connected to calomel half cells. Resting potentials were measured with a type K potentiometer; action potentials were recorded with an Offner condenser-coupled amplifier and crystograph. All animals used were dark-adapted 24 hours or longer and preparations were made under a weak red light. Constant intensity (expressed as foot candles, hereafter f.c.), constant duration (0.02 sec) test flashes were admitted at periodic intervals. Temperature varied in the range 23 to 25° C.

*Results.* 1. Experiments on excised intact eyeballs.

The results obtained varied with the intensity of the test flash. The protocols of typical experiments appear in Columns 1, 2 and 3, Table I. For low flash intensity (0.28 to 2.8 f.c.) the results are reasonably uniform and the ratio, $\frac{\text{action potential (b-wave)}}{\text{resting potential}}$ is fairly constant. For flash intensity of 28 f.c. the ratio is initially high and decreases during the experiment.

2. Experiments on excised enucleated eyes.

A protocol of a typical experiment appears in column 4, Table I. In general the action potential decreases as the resting potential

TABLE I.

Protocols from Experiments on Excised Intact Eyeballs, Col. 1, 2, and 3, and Excised Enucleated Eyeballs, Col. 4.

| | Intact excised eyeballs of the frog. | | | | | | | | | Enucleated | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flash int. = 0.28 f.c. | | | Flash int. = 2.8 f.c. | | | Flash int. = 28 f.c. | | | Flash int. = 2.8 f.c. | | |
| Elapsed time min. | Resting potential millivolts | b-wave magnitude millivolts | Ratio | Resting potential millivolts | b wave magnitude millivolts | Ratio | Resting potential millivolts | b-wave magnitude millivolts | Ratio | Resting potential millivolts | b-wave magnitude millivolts | Ratio |
| 0 | 5.560 | .288 | .051 | 5.950 | .270 | .045 | 6.300 | .400 | .063 | 6.795 | .495 | .073 |
| 15 | 4.340 | .168 | .039 | 3.508 | .100 | .029 | 4.662 | .214 | .046 | 4.951 | .442 | .089 |
| 30 | 3.419 | .168 | .049 | 1.390 | .076 | .055 | 3.223 | .106 | .033 | 3.722 | .410 | .110 |
| 45 | 2.503 | .140 | .056 | 1.594 | .079 | .05 | 2.246 | .052 | .023 | — | — | — |
| 60 | 1.863 | .122 | .066 | 1.335 | .066 | .05 | 1.464 | .039 | .026 | 3.142 | .417 | .133 |
| 75 | — | — | — | — | — | — | — | — | — | 2.715 | .362 | .133 |
| 90 | — | — | — | — | — | — | — | — | — | 2.473 | .350 | .142 |

[2] Brossa, A., and Kohlrausch, A., *Arch. Anat. Physiol.*, 1913, 449.

[3] Riggs, L. A., *J. Cell. and Comp. Physiol.*, 1937, **9**, 491.

decreases, but not in a relatively uniform manner. The ratio, $\frac{\text{action potential}}{\text{resting potential}}$, typically increases during the experiment.

*Discussion.* The parallel variations in magnitude of the resting and action potentials of the frog eye are in agreement with the observations of Brossa and Kohlrausch. These investigators measured resting and action potentials with the same electrodes and with the same recording device, a string galvanometer.

Under these conditions changes in contact resistance might conceivably affect both resting and action potential in the same manner. In the experiments reported here the same electrodes were used but with two types of recording instruments: a null-point type K potentiometer and a condenser-coupled high-gain amplifier. Changes in contact resistance would affect the amplified reading much more than the potentiometer reading. Therefore, the parallel variations in resting and action potential must be attributed to the photoreceptor.

The data obtained from excised intact eyeballs are rather uniform for flash intensities of 2.8 f.c. or lower. For higher flash intensities the magnitude of the action potential drops off more rapidly than does the resting potential, indicating inadequate recovery of sensitivity between test flashes. The data from the excised enucleated eyeballs indicate consistently action potentials whose magnitudes decrease much more slowly than do the resting potentials. This difference between intact and enucleated excised eyes may possibly be due to differences in retinal area illuminated.

In conclusion, the action potential obtained from intact and enucleated excised frog eyes in response to constant intensity, constant duration light flashes varies as the resting or demarcation potential. The electrical response of the excised eye to light is determined by the state of dark-adaptation and by the magnitude of the resting potential.

## 16426

## Fat and Nitrogen Absorption after Folic Acid Administration in Dogs Deprived of External Pancreatic Secretion.

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Interest in folic acid was aroused in this laboratory because of the similarity of the steatorrhea in sprue and in obstruction of the pancreatic ducts. Spies[1-5] and co-workers have contributed most notably to the advancing knowledge of folic acid. We wished to determine whether or not absorption of fat and nitrogen was influenced in pancreatic steatorrhea by the use of folic acid. In earlier work Spies *et al.*[5] mentioned that changes in the size and consistency of the stools in tropical sprue occur after treatment with folic acid, in that the stools became less bulky and more solid.

Darby and others[6] in a report of sprue cases from the Vanderbilt University Hospital state that stool examinations in 2 cases 2 months after treatment was begun still showed an increased fat content though diarrhea had

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1 Spies, T. D., *Lancet*, 1946, **1**, 225.

2 Spies, T. D., *J.A.M.A.*, 1946, **130**, 474.

3 Spies, T. D., Lopez, G. G., Menendez, J. A., Minnich, V., and Koch, M. B., *South. M. J.*, 1946, **39**, 30.

4 Spies, T. D., Vilter, C. F., Koch, M. B., and Caldwall, M. H., *South. M. J.*, 1945, **38**, 707.

5 Spies, T. D., Milanea, F., Menendez, A., Koch, M. B., and Minnich, V., *J. Lab. and Clin. Med.*, 1946, **31**, 227.

6 Darby, W. J., Jones, H. C., *J.A.M.A.*, 1946, **130**, 780.