To these should be added several values which have not appeared in the tables of physical constants hitherto published.

Capillary rise	73.1	Harkins and Brown
Capillary rise	73.1	Richards and Carver

We may take for granted that the values mentioned in the table were obtained under carefully controlled conditions of observation and that the observers were competent to analyze their problems from the standpoint of eliminating gross errors. The unweighted average of their results should therefore give a value whose probable error may be assumed as not greater than a few tenths of a dyne. This average (omitting the values of Weinberg and of the writer, since theirs are results obtained by the method which is being compared with the others) is 73.4. The value of 73.7 obtained by the duNoüy tensiometer differs by only .3 dyne from this average, an agreement which is closer than that of most of the individual values given in the table. In the case of pure water, therefore, the ring method comes as near qualifying as an "accurate" method as most of the methods cited in Freundlich's table.

At another point in his discussion MacDougall states that my procedure "is undoubtedly correct," with the exception of the method for correcting for the droplets adhering to the ring. Speaking of the correction for the droplets, he states, "I hope to show that the magnitude of the pull on the ring is independent of whether the droplets are formed on the ring or not." So far as I can discover, there is no demonstration of this point, unless the statement, "if there is in fact a maximum pull, it is evident that its magnitude will be independent of such phenomena as the actual breaking of the film and the adherence of droplets to the ring," can be so considered.[2] Beyond stating that the conclusion is by no means obvious, I refrain from arguing this question, because, according to the standard of "practical" accuracy, the correction for the droplets may be ignored without affecting the value of the data.

The ring method of measuring surface tension has its practical limitations, of course; but this statement is generally valid for all methods of physical measurement. From the standpoint of greatest accuracy in determining the physical constant of surface tension for pure liquids it is probably not so well suited as some others because of the complicated mathematical relationships[3] between the pull on the ring and the actual surface tension value. The fact remains, however, that for practical purposes these complicated relationships are of small importance in most cases, since the correction involved is small from the standpoint of practical accuracy. The ease with which the ring method can be used, the speed of measurement attainable, and the agreement with values obtainable by methods that involve most exacting refinements render the ring method one of the best, if not the best, for the study of the phenomena which are associated with changes in surface tension. This has been amply demonstrated in the work of duNoüy as reported at the Third National Colloid Symposium.

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[2] The phenomenon of maximum pull, whether the ring or a straight edge is used, was observed by investigators thirty or more years ago. See, for example, Arthur L. Foley, *Physical Review*, III O. S., 381, 1896.

[3] "Zur Theorie der Abreissmethode," J. J. Tichanowsky, *Phys. Zschr.*, 26, 1925, 522. Tichanowsky in this article gives a mathematical analysis of the ring method employing rings having different kinds of cross sectional shapes. In this paper he investigates a "ring" having infinite radius but leaves the ring with finite radius for a future paper.

SPECIAL ARTICLES

THE EFFECT OF ADRENALIN ON THE LUMINESCENCE OF FIREFLIES

In a recent paper by C. W. and H. H. Green[1] the effect of adrenalin on the luminous organs of *Porichthys notatus*, a California shore fish, was discussed. The authors found that an injection of adrenalin caused a brilliant glow of the luminous organs which persisted for several hours after the injection. From this and other experiments they came to the conclusion that the luminous organs of *Porichthys notatus* are hormone controlled rather than under nervous coordination.

It is interesting to note that an identical result is produced when adrenalin is injected into the body of a firefly (*Photuris pennsylvanica*). Although it is true that scattered masses of tissue of a similar staining reaction to that of the medulla of the suprarenal glands are known to occur in invertebrates, it is unlikely that the normal flashing of the firefly is controlled by hormones. The glow which is produced by the injection of adrenalin appears to be due to an abnormal condition resulting from the action of the drug on the myo-neural junction of the muscle

[1] "Phosphorescence of *Porichthys notatus*, the California Singing Fish," *Amer. Jour. of Phys.*, Vol. 70, 1924. Additional references given in these notes can be found, except when otherwise noted, in the bibliography of E. N. Harvey's monograph, "The Nature of Animal Light," or in that of his more recent paper, "Recent Advances in Bioluminescence," *Physiol. Rev.*, Vol. IV, No. 4, Oct., 1924.

fibers in the tracheal end-cells.[2] The normal flash of the insect is undoubtedly under nervous control. The innervation of the luminous organs has been described by a number of observers, notably Bongardt and Geipel, who found nerve fibers penetrating the tracheal end-cells. Within these cells are muscle fibers radially arranged around the tracheole in such a manner that their contraction increases the size of its lumen. The tracheole is surrounded by a small band which has been thought to be composed of circular muscle fibers.[3] Evidence from experiments with gases shows that the tracheoles are never completely closed in the normal insect. It seems more likely that the band is an elastic, chitinous ring which keeps the tracheoles partially contracted and serves as a point of attachment for the radial muscle fibers.

In general, adrenalin causes the contraction of smooth muscle, its point of action being the "receptive substance" in the myo-neural junction of nonmedullated nerves. Very little is known in regard to its effect on invertebrates, but if we assume that adrenalin causes the contraction of the muscle fibers of the tracheal end-cells, and through this the enlargement of the lumen of the tracheole, the explanation for the prolonged glow is obvious, since an abnormally large amount of air is admitted to the luminous tissue as long as the tracheoles are dilated.

A 1:1000 solution of adrenalin chloride was injected into the insect just posterior to the last pair of legs. The movements of the legs and abdomen, at first violent, gradually cease and with their cessation appears the steady glow. That this is not due to mechanical stimulation through pressure of the injected fluid may be shown by injecting physiological salt solution. In this case no glow occurs. Injected insects recover and show a normal behavior after about six hours.

The extent to which the adrenalin affects muscles other than those of the tracheal end-cells has not yet been thoroughly studied. It is certain that some of the other muscles are not contracted by the injection. The muscles of the occluding apparatus, structures which surround the base of each tracheal trunk just inside the stigma, compress the trachea by their contraction, thus preventing the entry of air into the tracheal system. Conversely, their relaxation permits free ingress of air. That these muscles are not contracted is shown by the reaction of an injected insect to an alternating atmosphere of oxygen and nitrogen. Under such conditions the glow of the luminous organ follows the alternation of the gases with beautiful precision, becoming brilliant in oxygen and being extinguished in nitrogen. This could not occur if the muscles of the occluding apparatus were contracted by the adrenalin, but it may be questioned whether they are relaxed or whether normal breathing movements continue after injection.

In order to see, if possible, the actual effect of the adrenalin on the tracheoles of the luminous organ a histological investigation of the tissue was made. The abdomens were cut from injected insects and normal controls and fixed at once in hot Bouin's fluid. An injected and normal abdomen were together embedded in celloidon and paraffin, cut at six microns and stained with iron-haemotoxylin. In the normal tissue the tracheoles could, in a few cases, be followed a short distance into the surrounding tissue. For the most part they could not be seen at all. In the adrenalin injected tissue the tracheoles were very prominent and could readily be followed through the tissue from one cylinder to another.

The results of this initial study of the action of drugs upon the luminescence of the firefly point to the following interpretation of the process:

The normal flash of the insect is directly due to nervous control, but it is also indirectly dependent upon breathing processes. During the respiratory cycle of an insect there is a phase when air is forced into the finest tracheoles by the coordinated contraction of the abdominal muscles and those of the occluding apparatus. Except when the insect is flashing, the air permitted to enter the tracheoles of the luminous tissue is regulated by the size of the elastic ring to an amount just sufficient for the respiratory needs of the luminous cells. By the contraction of the muscle fibers of the tracheal end-cells and the consequent distention of the elastic ring at the instant when the air in the tracheal system is under pressure a much greater amount of air is admitted to the tracheoles of the luminous organ, thus causing luminescence.

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[2] For a general discussion of the gross structure and the histology of the luminous organs of fireflies see Dahlgren, "The Production of Light by Animals," *Jour. Franklin Ins.*, March and May, 1917.

[3] Dahlgren, *loc. cit.*

THE OHIO ACADEMY OF SCIENCE

THE thirty-sixth annual meeting of the Ohio Academy of Science was held at the Ohio State University, Columbus, Ohio, April 9 and 10, under the presidency of President Paul M. Rea, of the Cleveland Museum of Natural History, Cleveland, Ohio. The attendance was unusually large and enthusiastic, and the program was well received. Sixty-nine new members were elected and five members were elevated to the rank of fellows in the academy, namely, J. H.