NOTE ON THE EXCITATION AND INHIBITION OF LUMINESCENCE IN BERŒ.*

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Berœ ovata is a large ctenophore which, when dark adapted, can display a brilliant blue-green luminescence. The luminous organs are distributed along the meridians marked by the swimming plates. In a dark adapted animal, weak stimulation causes local luminescence while strong excitation calls forth general luminescence from the meridians of the entire animal.[1] The rapidity of the conduction in general luminescence suggests that the mechanism is nervous.

In nature the phenomena of luminescence occur only at night. If specimens of *Berœ* be taken from the light at any time of day and placed in the dark room they at first show no luminescence even after vigorous excitation. But after half an hour in the dark they exhibit general luminescence when touched or agitated.

In order to determine the effect of ions on the luminescence of *Berœ*, experiments were carried out similar to those which we have reported for *Pelagia*.[1] In van't Hoff's solution *Berœ* behaves with reference to luminescence just as in sea water. If, however, one of the cations be omitted from the solution, the luminescent reactions of *Berœ* are greatly modified.

* The experiments on the reactions of *Berœ* and its luminescent material with ions were done at Naples in the spring of 1923. The quantitative data for the relation between the intensity of light and time of exposure required for the inhibition of luminescence were the result of experiments on specimens of *Berœ* taken from Barnegat Bay, New Jersey, October, 1924.

[1] Heymans, C., and Moore, A. R., *Compt. rend. Soc. biol.*, 1923, lxxxix, 430; *J. Gen. Physiol.*, 1923–24, vi, 273.

In van't Hoff's solution minus calcium, general luminescence is inhibited after 5 minutes, so that strong mechanical excitation of the animal yields only local luminescence. This proves the necessity of calcium ions for nervous conduction of the impulse causing general luminescence. Similar results are obtained if potassium alone is omitted from the van't Hoff solution.

The omission of magnesium from van't Hoff's solution leads to effects quite the reverse. When placed in such a solution *Berœ* responds by spontaneous and almost continuous luminescence, showing a condition of hyperirritability induced by the presence of Ca and K ions unantagonized by the Mg ion. These facts prove that the appearance and intensity of luminescence, as they result from nervous conduction, are dependent upon the composition of the external medium.

Luminescent indicator paper, prepared by spreading the luminescent material on filter paper, does not show luminescence if kept in the air, in sea water, in NaCl, or $MgCl_2$ or saccharose solutions. The solutions used are in all cases isosmotic with sea water and of reaction pH 7.8. In a solution of $CaCl_2$ the paper shows luminescence and remains glowing for about 12 minutes. $SrCl_2$ yields a similar result. In $BaCl_2$ the glow is briefer. In KCl solution the glow lasts 2 minutes; in K_2SO_4 solution, about the same length of time. The addition of alkali to the salt solution increases the intensity of the luminescence and at the same time shortens the duration of the glow. For example, when a piece of luminescent paper was put into a solution of 20 cc. $CaCl_2$ + 0.1 cc. N NaOH, a very bright luminescence appeared which lasted $2\frac{1}{2}$ minutes. These results extend the observations made with the luminous substance of *Pelagia* and confirm our former conclusions.

Just as in the case of *Pelagia* and *Mnemiopsis*,[2] so in *Berœ* exposure to light causes inhibition of luminescence. In order to determine the exact relations between the quantity of light and the time of exposure necessary for the suppression of luminescence in *Berœ* the following series of experiments was carried out.

The method was the same as that employed in the experiments with *Mnemiopsis*,[2] except that the light used was of 670 c.p. The tem-

[2] Moore, A. R., *J. Gen. Physiol.*, 1923–24, vi, 403.

TABLE I.

Relation between Intensity of Light and Time of Exposure Required for the Inhibition of Luminescence.

Intensity.	No. of animals.	Time.	$K = I \times t$
meter candles		*min.*	
1863	9	30	55,890
2680	12	22	58,960
4188	12	13	54,444
7437	12	8	59,496
		Weighted average = 57,285	

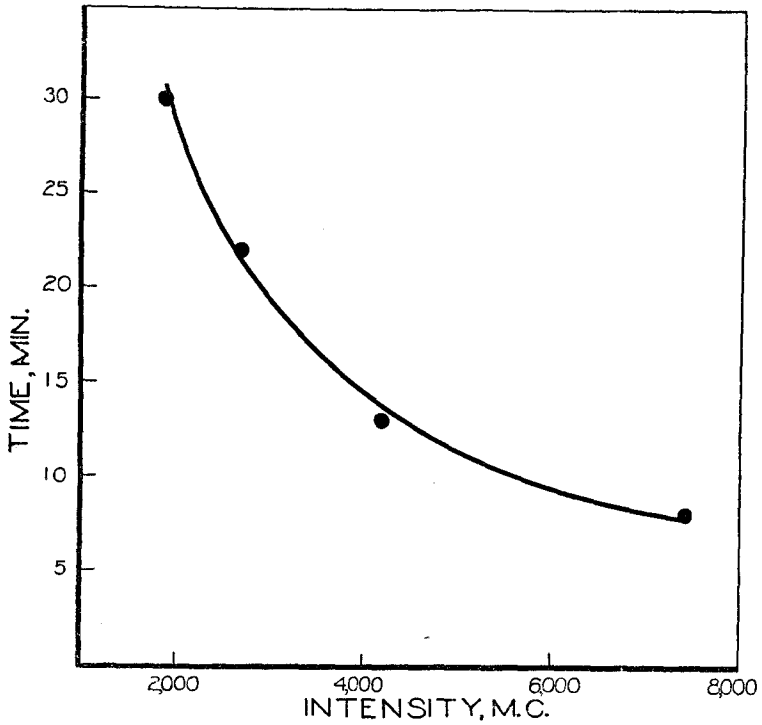

FIG. 1. Abscissæ represent intensities of light (I) and ordinates the average time (t) required at the intensity given to inhibit luminescence. The curve represents the calculated values of t for the intensities used, when $K = 57,285$ in which $K = I \times t$.

perature was 18–20°C. Four intensities were used with the result shown in the table and figure. The method of making the observations and computing averages was the same as described in the work on *Mnemiopsis*.

The product of the intensity of the light by the time necessary for suppression of luminescence in *Berœ* is a constant. This proves that *Berœ* is affected by light according to the Bunsen-Roscoe photochemical law.[3] The constant for *Berœ* has an average value of 57,285 meter-candle-minutes, which is approximately twelve times the magnitude of the corresponding constant obtained for *Mnemiopsis*.

CONCLUSIONS.

1. The ions of Ca and K condition general luminescence, and are therefore necessary to the conduction of the impulse.

2. In van't Hoff's solution from which Mg is omitted, *Berœ* shows hyperirritability with respect to luminescence. This is the result of the action of Ca and K ions unantagonized by Mg.

3. The luminescent material spread on filter paper does not show luminescence in sea water, NaCl, $MgCl_2$, or saccharose solutions isotonic with sea water. In solutions of $CaCl_2$, $SrCl_2$, $BaCl_2$, KCl, and K_2SO_4 the indicator paper glows with a bright luminescence.

4. In dark adapted *Berœ*, luminescence is inhibited by a certain quantity of light. This quantity has an average value of 57,285 meter-candle-minutes, which is twelve times the value given by *Mnemiopsis*.

[3] For discussion of the application of the Bunsen-Roscoe law to biological reactions, see Loeb, J., Forced movements, tropisms, and animal conduct, Philadelphia and London, 1918, 83.