THE EFFECT OF TEMPERATURE ON THE PHOTOTROPIC RESPONSE OF NECTURUS.

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It is a well known fact that *Necturus maculosus* is negatively phototropic. According to Eycleshymer (1906, 1908, and 1914) Reese (1906), and Pearse (1910), the animal always avoids sunlight in its natural environment as well as in the laboratory. They conclude that the skin is the important receptor for the photic stimulus since eyeless animals behave similarly to normal ones. It is also known that *Necturus* is sensitive to temperatures below 5° and above 25°C. (Reese, 1906; Sayle, 1916). I have found that the animals become more active when transferred from a temperature of 20° to one of 2°C., but that after several hours of exposure to the low temperature, they become very sluggish. As the temperature increases they show increased activity until death ensues between 35° and 40°C. Violent spasmic movements are characteristic of such high temperatures previous to death.

When illuminated, therefore, it may be assumed that the reaction time of *Necturus* will vary according to the intensities of the thermal and photic stimuli. The experiments reported here were performed to determine the effect on the reaction time of variations of the temperature in normal and eyeless animals, and to express it in quantitative form.

The animals were kept in a large aquarium with running water at 20°C. They were thus adapted to light of very low intensity and to a medium temperature. The animals were tested singly in a dark room, where the temperature and the light intensity could be easily controlled. They were placed in a rectangular blackened dish (170 cm. long, 11 cm. wide, and 8 cm. deep), and allowed 15 minutes for acclimatization. At the beginning of each trial, the animal was oriented in the center of the dish, with the longitudinal axes of the animal

and the dish parallel. One of the Mazda glowers was fixed above, so that the beam of light (10 cm. in diameter) centered on the head. When the glower was turned on, the animal crawled posteriorly until the head was out of the beam of light. This interval was designated the reaction time, and was measured by a stop-watch to the nearest second. The light was then turned out, and the animal given a rest period of 1 minute before the next trial began. Four intensities of light were used at four different temperatures on six animals. Ten trials were sufficient to obtain accurate averages before fatigue became apparent.

It was soon discovered that the reaction time of *Necturus* does not change much with the variations of light intensity from 1,875 candle meters to 8,000 candle meters. At a constant temperature of 22°C. and illumination of 1,875 candle meters, the average of sixty trials (ten on each animal) was 2.8 seconds while at 8,000 candle meters it was 3.1 seconds. At 2°C. the average for 1,875 candle meters was 8.1 seconds, and for 8,000 candle meters it was 8.3 seconds. The reaction time was not analyzed as to its exposure and latent periods, which were very short. Crawling began almost immediately after the light was turned on, so that the reaction time is really a measure of the time necessary for the animal to crawl out of the lighted area. Since it is improbable that this constitutes an exception to the Bunsen-Roscoe law, it is evident that in all the trials the maximum amount of stimulating substance was produced in a very short time, even at the lowest intensity. This would be true if the velocity of the photochemical reaction is high enough at 1,875 candle meters. The determination of the exposure period in its relation to the photic intensity was reserved for future investigation. In all the temperature tests only one intensity of light was used, 4,200 candle meters.

From Fig. 1 it will be seen that the reaction time varies inversely to the temperature. Between 2° and 32°C. the temperature coefficient gradually diminishes, as it does in other animals (Hecht, 1919), although its numerical value is not especially significant, since the several chemical processes underlying the reaction time of *Necturus* have not been analyzed. At 32°C. the animal probably moves as fast as its anatomy will allow, without showing the spasmic movements characteristic of temperatures above 35°C. The curve expresses in

definite form the effect of temperature on the phototropic response of *Necturus*, and it may be concluded that the decrease in the reaction time is due to an increase in the velocities of the chemical processes

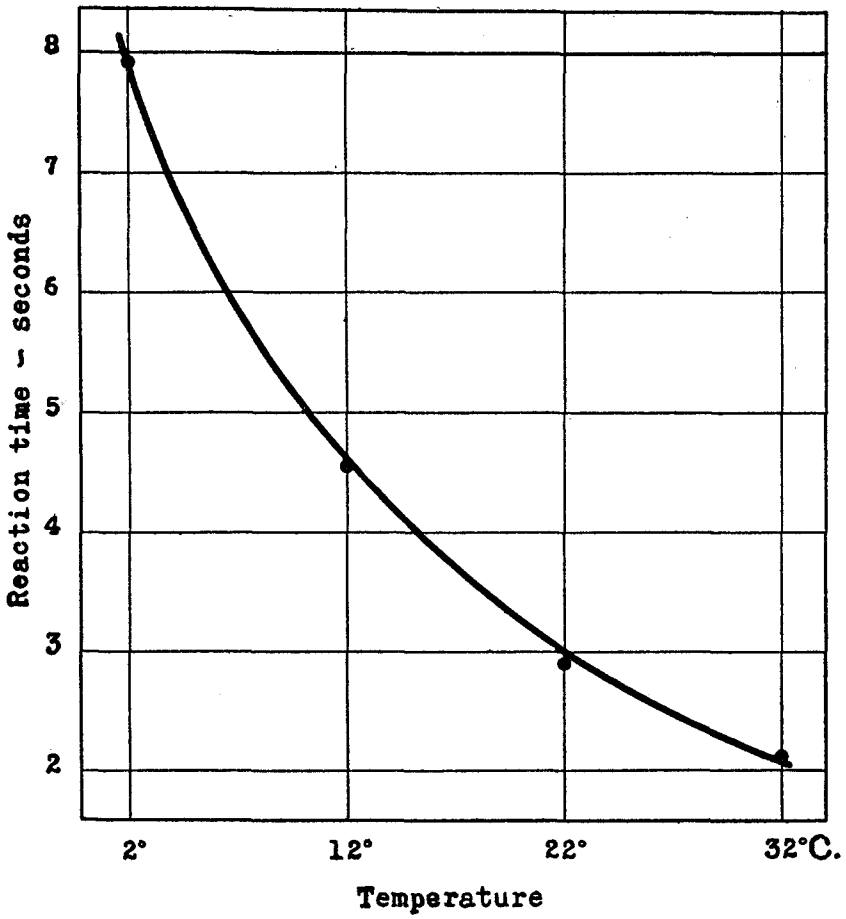

FIG. 1. Relation between temperature and reaction time. Each point is the average of sixty trials; ten on each of six animals. Intensity of light, 4,200 candle meters.

which cause muscular movements, and not to any effect of the temperature upon the photochemical reaction.

48 hours after the eyes had been removed, the six animals were tested again at each of the four temperatures, and with a light inten-

sity of 4,200 candle meters. The averages obtained were almost identical with those from normal animals. It is therefore concluded that the skin is the important receptor for the photic stimulus.

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