

a green color; lactic acid, a royal blue; oxalic acid, a green; mucic acid and citric acid, dark blue; tartaric acid, a royal blue with a purplish tinge; and pyruvic acid, green.

The reagent, however, is more sensitive to the sugars than to the organic acids. The limit of sensitivity for glucose is 0.03%. Citric acid reduces in a 3% solution, but not in a 2% solution. Tartaric acid reduces in a 2% solution, but not in a 1% solution. Lactic acid does not react in a 0.9% solution. Oxalic acid gives a faint reaction in a 4% solution, but no reaction in a 3% solution. Pyruvic acid gives a green color in a 5% solution, but not in a 4% solution. Mucic acid proves positive in a 3% solution, but not in a 2.5% solution. Cysteine hydrochloride gives a green color in a 0.5% solution, but no color in a 0.25% solution.

Chloroform, uric acid and allantoin, creatinine, formaldehyde, acetaldehyde, acetone and β -hydroxybutyric acid do not respond. Ethyl acetoacetate reacts in the negative, but after hydrolysis with dilute hydrochloric acid it gives a faint green color. Proteins do not interfere with the reaction.

5228

Oxygen Consumption of the Cardiac Ganglion of *Limulus Polyphemus*.*

MARGARET DANN AND EDITH M. GARDNER.

(Introduced by W. H. Chambers.)

From the Marine Biological Laboratory, Woods Hole, Mass.

The CO₂ production of the cardiac ganglion of *Limulus* has been studied by Garrey,¹ who found a direct quantitative relation between the rate of the heart beat and the rate of CO₂ formation in the ganglion. Both of these rates were augmented when the ganglion was stimulated chemically, mechanically, or electrically, and diminished when the inhibitory nerves were stimulated.

The object of our experiments was to study the oxygen consumption of the ganglion during rest and during electrical stimulation.

* This work was performed under the direction of Dr. W. E. Garrey and Dr. R. W. Gerard as a part of the Physiology Course of 1930 at the Marine Biological Laboratory, Woods Hole, Mass. We wish to acknowledge our indebtedness to them for their advice and help and for permission to publish our results.

¹ Garrey, W. E., *J. Gen. Physiol.*, 1920, **3**, 163; 1921, **4**, 149.

The method employed was the Warburg manometric technique.² For stimulation experiments we used chambers with simple manometers and platinum electrodes sealed in, as employed by Gerard.³ The ganglia were kept in sea water instead of Ringer's solution. At least 5 ganglia, having a combined moist weight of about 0.1 gm., were used. After careful dissection they were kept cold until mounted on the electrodes, after which the experiment was conducted at a temperature of 24.6 to 24.8°C.

Readings were taken every 10 or 15 minutes for a period of about 3½ hours. After a resting period of one-half to one hour, stimulation was applied for 10 minutes at the rate of 2 shocks (one make and one break) per second by means of a Harvard inductorium with coil set at about 4 cm. and one dry cell. Another resting period of about 40 minutes was allowed to elapse before the next stimulation was given, and this procedure was repeated several times. At the end of the experiment the dry weight of the ganglia was obtained, and from this the moist weight was calculated on the basis of 80% water.

The table shows results obtained in 3 experiments when stimulation was given. The average resting value for these 3 experiments was 104 cu. mm. of oxygen per gm. of moist weight per hour, with variations between 93 and 120 cu. mm., while the average obtained in 9 experiments was 114 cu. mm., with variations between 30 and 217. Precautions as to condition and number of ganglia used were observed with especial care in the experiments of July 25, 28, and 29.

The depression of oxygen consumption which accompanied elec-

TABLE I.
Oxygen Consumption of Ganglia per Hour.
Cu. mm. per gm. moist weight.

	July 25*	July 28*	July 29†
Rest	117	97	99
Stimulation	34	24	0
Rest	107	103	110
Stimulation	26	11	94
Rest	127	93	93
Stimulation	0		63
Rest	111		98
Stimulation			44
Rest			120
Stimulation			50
Rest			116

* Stimulation of posterior ends of ganglia.

† Stimulation of anterior ends of ganglia.

² Warburg, O., *Über den Stoffwechsel der Tumoren*, Berlin, 1926.

³ Gerard, R. W., *Am. J. Physiol.*, 1927, **82**, 381.

trical stimulation of the posterior ends of the ganglia was very striking in its magnitude and consistency of appearance. The average depression amounted to over 80% of the resting oxygen intake. A similar effect, but in a lesser degree, was observed when shocks were applied to the anterior ends of the ganglia. There was a prompt return to the resting rate when stimulation ceased.

Stimulation, at the rate of 2 shocks per second, of the ganglion of an isolated *Limulus* heart preparation was found by Asher and Garrey⁴ to produce definite depression of the heart rate, and this was confirmed by Garrey and Knowlton,⁵ who also found that stimulation at a faster rate produced complete inhibition of the entire ganglion. Therefore it is probable that the fall in oxygen consumption which we observed was due to inhibition. This is in harmony with Garrey's conclusion¹ that inhibition involves a decrease in cellular metabolism.

5229

A Life Cycle of a Thermophilic Organism.

C. S. MUDGE.

From the Department of Agriculture, University of California, Davis, Calif.

Numerous investigators have described organisms capable of growing at 62°C. This is the accepted pasteurization temperature for milk. In all of the descriptions of such thermophilic phenomena, especially where milk is concerned, one characteristic has been quite apparent—that is, sharp rather than gradual increases in bacterial numbers. Our observations have been in accord with those described in the literature. Calculation of the generation time for these increases has disclosed values of 5 to 8 minutes. It was thought that such short generation times were in little accord with accepted views. The only alternative was to consider the phenomena as evidence of something other than growth. Spores are usually present at the same time vegetative cells appear in smears of milk. It has been assumed that these spores are germinating rather than that the vegetative cells are sporulating. If spores exist in milk which shows thermophilic growth they must be present in large numbers.

⁴ Asher, L., and Garrey, W. E., *Am. J. Physiol.*, 1930, **94**, 619.

⁵ Garrey, W. E., and Knowlton, F. P., (personal communication).