Brilliant Vital Red from the blood stream in experiments on 5 out of 8 animals. Experiments on 3 animals showed no appreciable effects. Blood volume as determined by hemoglobin changes was not altered in the Vital Red studies. These and previous findings lend support to the idea that many of the effects of pituitrin administration are due to a lessened exchange of material between the blood and tissues.

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Effect of Various Ions upon the Heart Rhythm of Crayfish (Cambarus clarkii).

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Using perfusing solutions of various salts approximating in ionic concentrations those found by Griffith[1] to be present in the blood of *Astacus fluviatilis,* an attempt was made to determine the effect of the Na, K, Ca, and Mg ion upon the intact heart of the Crayfish *(Cambarus clarkii).* For comparative purposes a control perfusing solution containing 1% NaCl+0.028%—KCl+0.024% $CaCl_2$ was employed. Such a solution applied to the heart maintained the normal rhythm for a period of several hours when perfused at a temperature of 25±0.1 degrees centigrade. Graphic records were obtained of the heart rhythm while being perfused with the various solutions.

In determining the effect of the Na ion, 3 perfusing solutions were employed, viz.: A pure solution of 1% NaCl, one containing 2% NaCl+0.028% KCl+0.024% $CaCl_2$ and one containing 0.028% KCl+0.024% $CaCl_2$. Both solutions containing Na produced a marked increase in rate and amplitude of the beats coupled with a loss in tone. The pure 1% solution had an especially marked effect upon the tone. The solution lacking Na produced a sharp increase in the tone accompanied by a loss in amplitude and rate, the heart generally stopping in diastolic arrest in less than 20 minutes. It may be noted in this connection that Carlson,[2] working upon Limulus, found that the Na stimulates the heart and increases the amplitude of the beats. Hogben[3] noted that in Maia and Homarus a pure solution of NaCl produced an almost immediate increase in

[1] Griffith, A. B., "The Physiology of the Invertebrata." New York, 1892.

[2] Carlson, A. J., *Ergebnisse der Physiol.,* 1909, viii, 372.

[3] Hogben, L. T., *Quar. J. Ex. Physiol.,* 1925, xv, 263.

tone, resulting shortly in systolic arrest. Rogers[4] observed that NaCl had the power of restoring rhythmatic contractions in the heart of the crab *(Brachnotus nudus)*. It is concluded from the present work that the Na ion increases the rate and amplitude and decreases the tone of the crayfish heart and is, therefore, concerned in the regulation of normal heart rhythm.

Similar experiments were performed with solutions of KCl and $CaCl_2$. A pure solution of 0.024% $CaCl_2$ produced a sharp increase in tone and a slight decrease in the rate. Increasing the $CaCl_2$ the control perfusing solution affected the rate only, the latter being decreased slightly. A pure solution of 0.028% KCl invariably depressed the rate and amplitude but had slight if any effect upon the tone. The removal of K from the control perfusing solution resulted in systolic arrest of the heart in less than 30 minutes. Normal rhythm could subsequently be restored only upon the replacement of KCl in the perfusing solution. In regard to the effect of K and Ca upon the heart rhythm of other closely related species, Hogben[3] finds that in Maia an excess of K produces systolic arrest of the heart. Carlson[2] observed that K and Ca both produced depressor action upon Limulus heart muscle. The present work is similar to the above in that K and Ca depress the rate and amplitude and increase the tone of the Crayfish heart, the Ca ion having an especially pronounced effect upon the tone.

The intact heart of the Crayfish was found to beat normally in the absence of Mg from the perfusing solution. Small additions of $MgCl_2$ to the control perfusing solution had no effect upon the normal rhythm. However, when the concentration of $MgCl_2$ was considerably increased (to about 0.1%) the rate decreased somewhat. The results obtained indicate that the Mg ion is not essential for the maintenance of normal heart rhythm in the Crayfish.

Normal perfusing solutions in which the hydrogen ion concentration had been altered by means of HCl, CO_2, and NaOH produced no marked effects upon the normal heart rhythm within the range of pH 5.5 to 9.0. Decreasing the pH below 5.5, however, resulted in a marked increase in tone. Hogben[3] likewise noted that the hearts of *Homerus* and *Maia* were extremely insensitive to changes in hydrogen concentration and that the heart would continue to function normally in a perfusing solution having a pH as low at 5.6. It is evident, therefore, from the present results, that the crayfish heart is capable of marked adaptation in this respect and can maintain its normal rhythm within a considerable range of hydrogen ion concentration.

[4] Rogers, C. G., *J. Exp. Zool.*, 1905, ii, 237.