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Summation of Contractions in the Turtle Heart.

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The phenomenon of summated contractions cannot be obtained in cardiac muscle under ordinary conditions. Mines,¹ however, found such an effect in the hearts of *Torpedo ocellata* which had been removed from the body for some time. He related this exception to the fact that the extraordinarily long refractory period of the heart had been shortened under the experimental conditions. Thus a second stimulus occurring sufficiently soon after a first would allow summation of one contraction upon another. Burridge² found that calcium salts greatly favored summation in frog ventricle muscle. Alcohol, ether, and alkali also had a somewhat similar effect.

In this laboratory while studying the vagus effects on the turtle heart it was discovered that in a limited number of cases extra-contractions could be summated upon normal contractions during vagus inhibition.

In these investigations hearts of *Chrysemys elegans* and *Chrysemys troosti* were used. It was found that summation of contractions was possible in either auricle with homolateral vagus stimulation, but the right auricle because of its greater size and contractility always demonstrated the phenomenon to an advantage. Accordingly, the right auricle was used in most of the experiments, its contractions being recorded on a smoked surface by means of a sensitive isometric lever. Since the negative chronotropic effect of the right vagus in this genus generally overshadows its negative inotropic action, it was found necessary to maintain rhythm of the auricles artificially during inhibition. This was accomplished by

¹ Mines, G. R., *J. Physiol.*, 1913, **46**, 1.

² Burridge, W., *J. Physiol.*, 1913, **47**, 31.

sending rhythmical break shocks into the non-recording auricle, thus maintaining contractions in all parts.

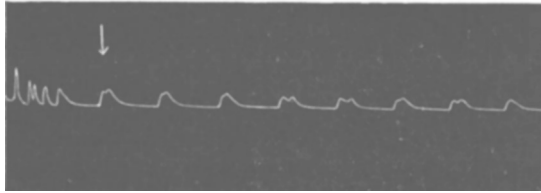


FIG. 1.

Representing summation of contractions in turtle auricular muscle. The left vagus and left auricle were used in this illustration.

Fig. 1 is a characteristic result showing that an extra-systole during the period of vagus stimulation will produce a total height of contraction surpassing that of the regular driven beat. This is true only when this extra-contraction occurs within a short time after the normal, approximately 1.5 seconds in most cases at room temperature.

In order to obviate the difficulties of recording such slight amounts of tension on the smoked surface an optical lever was employed and records of the amplitude of contractions were read directly from the excursions of a beam of light upon a centimeter scale. The effects were the same as those illustrated graphically and are shown in Table I. As the interval between the normal and

TABLE I.

Total height of extra-contraction	Height of regular beat, 0.7 cm.	
	Interval between regular and extra-contraction	
em.		sec.
1.1		0.2
0.9		0.4
0.7		1.4

extra-contractions approaches 1.5 seconds, the amplitude of the contractions of the normal and extra beats becomes approximately equal.

It will therefore be apparent that summation of contractions is possible in turtle atrial muscle during vagus inhibition. The observed shortening of the refractory phase may be partially responsible for the described phenomena. Perhaps a sufficient increase in the rate of the recovery process together with a decrease in the refractory period may be the underlying cause. Further work along this line remains to be done.