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Diffraction Spectra of Striated Muscle and the Mechanism of Contraction.

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Previous work[1, 2, 3] on the diffraction patterns produced by striated muscle at normal, stretched, and contracted lengths, has shown in general that s, the sarcomere length, can be calculated from measurements of the angles of diffraction, Θ_n, by means of the diffraction grating equation $n\lambda = s \sin \Theta_n$, where $n =$ the spectral order, and $\lambda =$ the wave length of the light. In the present work records have been obtained of the variations of the diffraction pattern, along with the simultaneously produced tension response, of the frog sartorius during isometric twitch. A set of only about 400 striations along the length of the muscle near the nerve plexus is used to form the diffraction spectra. It is thus possible, using the above equation, to compare changes in the length of the sarcomeres of these striations, with changes in the state of the whole muscle at each instant of muscle activity.

Fig. 1 shows 2 records obtained from different sartorii stimulated with supermaximal break shocks. Starting with the lowest band

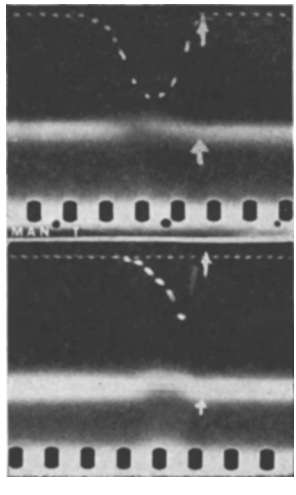

FIG. 1.
Tension and Diffraction Variations of Frog Sartorius During Isometric Twitch.

1 Ranvier, L., *Arch. de Physiol.*, 1874, **6**, 774.

2 Vlès, F., *Propriétés Optique des Muscles* (Chapter 2), Paris, 1911.

3 Sandow, A., *Bull. Am. Phys. Soc.*, 1933, **8**, No. 5.

each record includes: the undiffracted beam, the first order spectrum, and the tension record, the dashes indicating 0.01 sec. intervals. The arrows mark the instant at which the tension response begins.*

Although the unsharp edges of the spectra permit only a rough analysis, several features are nevertheless quite plain. The first order spectra persist during contraction; hence it follows that the striations likewise persist. The upward displacement of the spectra is the consequence of an increase in the angle of diffraction; since n and λ are constant, s must decrease. The rough measurements show that at the peak of contraction the percentage decrease in s is of the same order as that of the length of the entire muscle.

The persistence of the spectra and the extent of their displacement during contraction bear on the view of Jordan[4] that "contraction is a matter of the equal division of the dark stainable materials of the Q discs and the movement of the resultant semi-discs in opposite direction against the limiting telophragmata of a sarcomere. Relaxation is the reversal of this process." If this description is correct for isometric contraction, there should be doubling of the number of striations per unit length of muscle during the contraction period and again during the relaxation period. In our records such behavior would cause during these periods a displacement of the first order spectra to a position at approximately twice the distance of the resting first order spectra from the undeviated beam. Since this does not occur, we must conclude that Jordan's description does not hold for the isometric twitch of the frog sartorius.

Finally, it can be noticed that displacement of the spectra begins simultaneously with, if not slightly earlier than, the instant at which the tension response starts. The entire variation of the spectra during the twitch is over in about 60σ, whereas the tension record requires more nearly 90-100σ for completion. This means that under the conditions of our experiments the changes in the length of the sarcomeres do not parallel the changes in length of the entire muscle during an isometric twitch. A similar time difference between double refraction, and tension changes during isometric twitch has been found by von Muralt;[5] and Gasser and Hill[6] have

* The two arrows are not in line, since for technical reasons the diffraction, and the tension recording beams did not pass through the slit of the recording camera at the same angle.

4 Jordan, H. E., *Physiol. Rev.*, 1933, **13**, 301.

5 Von Muralt, A., *Pflüg. Arch.*, 1932, **230**, 299.

6 Gasser, H. S., and Hill, A. V., *Proc. Roy. Soc. B.*, 1924, **96**, 398.

concluded that the fundamental mechanical response of muscle has a different time course than that of tension development of the whole muscle. It is hoped that further research on sarcomere behavior by means of the muscle diffraction patterns will help elucidate some of these problems of the mechanism of contraction.

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Ascorbic Acid Oxidase in Determining Vitamin C in Lens and Aqueous Humor.

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The vitamin C content of the eye has been the subject of a great deal of speculation by investigators. In the normal lens and aqueous, there is an appreciable quantity of the vitamin. In the cataractous lens, however, this quantity is markedly decreased.[1, 2]

At first, biological methods were used for determination of vitamin C. Later, it was estimated by titration with Tillman's reagent, 2, 6-dichlorophenolindophenol. It was accepted that reduction of the dye at pH 2 was entirely due to vitamin C. However, so far as the lens is concerned, this has been challenged by Fujita, Iwatake, and Miyata,[3] who, by use of Folin's tungstate reagent, have found that only 79% of the reduction of indophenol depends upon vitamin C. Tauber, Kleiner, and Mishkind[4] recently found in the Hubbard squash an oxidase enzyme which is specific for vitamin C. Use of this, then, should furnish direct evidence as to whether the substance in the lens and aqueous, which reduces the dye, is totally vitamin C.

We first undertook to substantiate the work of Tauber, *et al.* The results of our experiments on the action of the oxidase at various pH values are given in Table I.

As seen from our data, the optimum pH range of the enzyme is 5.5-6.0,—which confirms the work of the previous investigators.

1 Mueller, H. K., and Buschke. W., *Arch. f. Augenheilkund*, 1934, **108**, 592.

2 Bellows, J., *Arch. of Ophth.*, in press.

3 Fujita, A., Iwatake, D., and Miyata, T., *Biochem. Z.*, 1935, **277**, 296.

4 Tauber, H., Kleiner, I. S., and Mishkind, D., *J. Biol. Chem.*, 1935, **110**, 211.