be a contributing factor. According to the literature reviewed by the writer, there appear to be several additional instances of marked similarity between the distribution of certain mosses and conifers, but these have not been verified in the field.

Voucher specimens for the new stations of both species in the coast redwood forest will be deposited in the Herbarium of the University of Michigan.

The parallel geographical distribution in California and Oregon for the coast redwood and two mosses *F. pauperculus* and *O. gracile* is considered to be evidence for the previously formulated hypothesis that there is a close correspondence between the distribution of many mosses and conifers. The occurrence of *O. gracile* in isolated stations in Europe may be explained on the basis that mosses, because of their small size, may survive in microhabitats in areas where larger plants of similar ecological amplitude or tolerance (*10*) are unable to exist. The principle of microhabitats (*11*) promises to be of far-reaching significance in the study of the distribution of the smaller terrestrial organisms.

References

1. KOCH, L. F. Ph.D. thesis, Botany Dept., Univ. Mich. Microfilm Pub. (1951).
2. ANDREWS, A. L. *Bryologist*, **35**, 49 (1932).
3. KOCH, L. F. *Ibid.*, **51**, 30 (1948).
4. *Ibid.*, **52**, 84 (1949).
5. SHIRLEY, J. C. *The Redwoods of Coast and Sierra.* Los Angeles and Berkeley: Univ. Calif. Press (1947).
6. HOWE, M. A. *Erythea*, **2**, 97 (1894).
7. KOCH, L. F. *Leafl. West. Botany*, **6**, 1 (1950).
8. HOWE, M. A. *Erythea*, **4**, 48 (1896).
9. MARGADANT, W. D., and MEIJER, W. *Trans. Brit. Bryol. Soc.*, **1**, (4), 266 (1950).
10. GOOD, R. *The Geography of Flowering Plants.* London–New York: Longmans, Green (1947).
11. WOLFE, J. N., *et al. Ohio Biol. Survey*, **8**, 1 (1949).

Skeletal Muscle Changes in Scurvy with a Note on the Mechanism of the Attachment of Myofibrils to Tendon[1,2]

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It has long been known that degeneration of striated muscle is common in scurvy. Hyaline degeneration and fragmentation of the fibers, with great proliferation of nuclei are usually described. Dalldorf (*1*) noted that these changes varied with the degree of muscular activity and regarded them as part of the scorbutic syndrome, but Aschoff and Koch (*2*), Goettsch and Pappenheimer (*3*), and Wolbach (*4*) did not consider them to be specific to this disease. Others (*5–7*) have also described these changes in scurvy. Murray and Kodicek (*8*) studied guinea pigs who were receiving suboptimal doses of ascorbic acid, and whose fibulas had been fractured. The fibers of the adjacent muscles degenerated, and the sarcoplasm and myofibrils were removed by invading wandering cells. This phenomenon was interpreted as due to an increased degree of susceptibility to injury of the muscle of animals on diets deficient in ascorbic acid.

FIG. 1. Longitudinal section of thyroarytenoid muscle of guinea pig #25, which was on the scorbutigenic diet plus 0.5 mg ascorbic acid daily for 77 days. This and other sections were stained with hematoxylin and eosin. This section shows normal fibers and those in the early and late stages of hyaline degeneration, with much nuclear proliferation. ×400.

In the course of an investigation of the bones and teeth of scorbutic guinea pigs, the present writers noted that the hyaline and proliferative changes described by the above-mentioned workers occurred frequently in the muscles around the knee joint, ribs, scapulas, and tracheas of animals receiving suboptimal doses of ascorbic acid for long periods (Fig. 1).

In acute scurvy, hyaline degeneration of these muscles was much less common. The finer structure of the muscle fibers became prominent, showing clearly the myofibrils and cross striations. The sarcoplasm seemed to be reduced in amount. Finally the fibers pulled apart. Nuclear proliferation occurred but to a less degree than in chronic scurvy (Fig. 2).

The changes in the muscles around the temporomandibular joints differed in both chronic and acute scurvy from those described above. Hyaline changes were only occasionally observed in chronic scurvy. In acute scurvy, areas were found where the muscle fibrils and sarcoplasm were seen to end suddenly, leaving intact and empty sarcolemma sheaths between

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which the endomysium fibers could often be distinguished (Fig. 3). A similar phenomenon is said to occur when muscle is put into hot water (*9*). Proliferation of nuclei, so conspicuous in other muscles, was absent. This change occurred at the insertion into the periosteum and also in the body of the muscle. In some cases the sarcoplasm and fibrils had a torn and serrated edge; in others, they suddenly faded away. The transverse striations of these torn fibers were not lost, as occurs in hyaline degeneration, nor were the fibers swollen. The longitudinal myofibrils became conspicuous. In some cases individual fibers stood out because of their eosinophilic staining, which was possibly due to an early degenerative change. Other muscle insertions, together with periosteum, might have torn off the bone, accompanied by hemorrhage, as is usual in scurvy, but this was a different phenomenon from that described above.

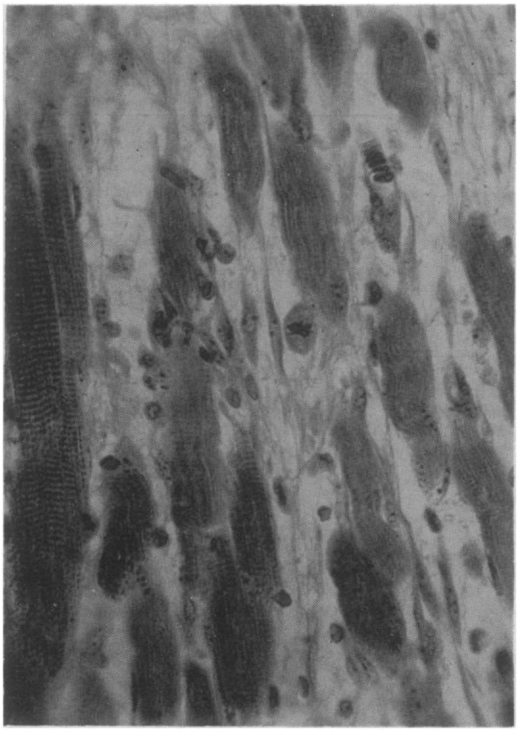

FIG. 2. Longitudinal section of intercostal muscle of guinea pig #100, which was on the scorbutigenic diet for 23 days. Fibers have broken up into short lengths, and their longitudinal and transverse striations are prominent. Moderate degree of nuclear proliferation, not so marked as in Fig. 1. A mitotic figure is seen in the middle of the field. × 400.

The attachment of muscle fibers to tendon or periosteum has long been a subject of controversy. Carr (*10*), among recent workers, upheld the view that the myofibrils continued into the tendon fibrils, the fate of the sarcolemma being uncertain. Goss (*11*) found that in both tendinous and periosteal junctions the muscle fibers ended completely and were attached by an argyrophil network, there being no continuation of myofibrils or of sarcolemma. Schultze (*12*), many years ago, proposed a compromise view that the

FIG. 3. Longitudinal section of the insertion of the external pterygoid muscle of guinea pig #99, which was on the scorbutigenic diet for 24 days. The mandibular periosteum is at the bottom. The sarcoplasm and fibrils have retracted in their sarcolemma sheaths, which are left intact and between which endomysium can be seen in some areas. × 400.

sarcolemma was pierced at its end by the myofibrils continuing into the tendon.

The present findings support the views of Goss, since the myofibrils pulled back, leaving an unaltered sarcolemma sheath. Had the myofibrils and sarcolemma been attached together at the periosteum, they would presumably have collapsed together. Ascorbic acid appears to be essential for the maintenance of the attachment of myofibrils to the sarcolemma.

The present writers feel that material such as theirs, obtained from a study of a deficiency state, could be used to advantage in investigations of normal structure, since the changes that occur are often a type of natural micromanipulation.

References

1. DALLDORF, G. *J. Explt. Med.*, **50**, 293 (1929).
2. ASCHOFF, L., and KOCH, W. *Veröffentl. Gebiete Kriegs-u. Konstitutionpathol.*, **1**, 1 (1919).
3. GOETTSCH, M., and PAPPENHEIMER, A. M. *J. Exptl. Med.*, **54**, 145 (1931).
4. WOLBACH, S. B. *J. Am. Med. Assoc.*, **108**, 7 (1937).
5. HOJER, J. A. *Acta Paediat.*, **3**, Supp. 7 (1924).
6. MEYER, A. W., and MCCORMICK, L. M. *Stanford Univ. Pubs., Med. Sci.*, **2**, 2 (1928).
7. RINEHART, J. F. *Ann. Internal Med.*, **9**, 671 (1935).
8. MURRAY, P. D. F., and KODICEK, E. *J. Anat.*, **83**, 158 (1949).
9. BREMER, J. L., and WEATHERFORD, H. L. *A Text-book of Histology*, 6th ed. Philadelphia : Blakiston (1944).
10. CARR, R. W. *Am. J. Anat.*. **49**, 1 (1931).
11. GOSS, C. M. *Ibid.*, **74**, 259 (1944).
12. SCHULTZE, O. *Arch. mikroskop. Anat. Entwicklungsmech.*, **79**, 307 (1912).