

## A Geometrical Determination of the Extracellular Space in Muscle.

ALEXANDER SANDOW. (Introduced by Harry A. Charipper.)

*From the Department of Biology, Washington Square College, New York University.*

Fenn<sup>1</sup> and his collaborators have demonstrated that 14.5% of the volume of the freshly excised frog skeletal muscle is unique in that it contains all the chloride of the muscle. This part of the muscle has been called the chloride space and the inference has been drawn that it is identical with the extracellular spaces. The purpose of this note is to add to the existing evidence in favor of this inference a purely geometrical demonstration that the extracellular spaces may well comprise some 15% of the muscle volume.

Consider a muscle, such as the sartorius, made up of parallel cylindrical fibers of diameter  $D$ , and let us calculate  $r$ , the ratio of the volume of the fiber space to that of the total space. In any thin cross-sectional segment of the muscle  $r$  will be given by the ratio of the area of all the fiber cross-sections to that of the entire cross-section. Assuming a regular arrangement of the fibers along the whole length of the muscle, it is clear that  $r$  for the whole muscle will be known if the ratio of the areas for any cross-section can be determined. And this can be calculated if some assumptions are made as to the nature of the packing of the fibers.

We may assume two ideal limiting types of packing, A and B (Fig 1.) If the packing is the A-type, the number of fibers per  $\text{cm}^2 = 1/D^2$ , and since the cross-sectional area of a fiber  $= \pi D^2/4 \text{ cm}^2$ , the total area of the fibers in a  $\text{cm}^2$  of muscle cross-section  $= \pi/4 \text{ cm}^2$ . Therefore,  $r = \pi/4 = 0.785$ . If the packing is assumed to be of the B-type, then since the number of fibers of diameter  $D$ , per unit area of cross-section, is  $2/\sqrt{3} \times$  the number for the A-type,  $r = 2/\sqrt{3} \times 0.785 = 0.906$ . Now it seems reasonable to believe that neither of these two types of packing is found in the actual muscle to the exclusion of the other. Both are probably present. If we assume that both are equally prevalent then we must take as the true theoretical value of  $r$  the average of the two values calculated above. This turns out to be 0.846. Therefore the geometrically determined value of the extra-fiber space is 0.154, *i. e.*, 15.4%, of the volume of the entire muscle.

<sup>1</sup> Fenn, W. O., Cobb, D. M., and Marsh, B. S., *Am. J. Physiol.*, 1934, **110**, 261.

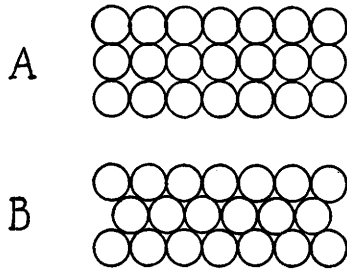


Fig. 1

Needless to say this is a highly simplified and idealized method of calculating the extracellular volume in muscle. No account, for example, has been taken of the effect of variation in the diameter of the fibers, nor of the effect of possible crowding and so distortion of the circular cross-section that has been assumed for the fiber. These and other factors, however, cannot be checked by reference to slides of actual cross-sections of muscle since the fibers suffer unpredictable alterations in the preparation of the sections. At any rate, the result obtained above is in striking agreement with Fenn's value of 14.5% for the chloride space, and in so far as the above considerations have validity they may be accepted as helping to confirm Fenn's conclusion as to the identity of the chloride space and the extracellular space in muscle.

11048

**A Peculiar Reproductive Process in Colon Bacillus Colonies.\*†**

L. DIENES.

*From the Department of Pathology and Bacteriology of the Massachusetts General Hospital, and the Robert W. Lovett Memorial for the Study of Crippling Disease, Harvard Medical School, Boston.*

In a previous publication attention was called to the fact that colonies resembling the L type colonies of *Streptobacillus moniliformis* develop in various bacterial cultures.<sup>1</sup> Observations to date

\* The expenses of this investigation were defrayed in part by a grant from the Commonwealth Fund.

† This is publication No. 39 of the Lovett Memorial.

<sup>1</sup> Dienes, L., PROC. SOC. EXP. BIOL. AND MED., 1939, 42, 636.