

the case at the later stages, for in the innermost layers of the exomeristem no more radial walls are formed, so that consequently the tangential diameter of these cells becomes very great. In the endomeristem, divisions having taken place freely towards the periphery, the junction of the tissues is made plain by the small-celled endomeristem abutting directly on the large-celled exomeristem. For some time the layer of exomeristem immediately surrounding the endomeristem remains unchanged, but eventually each cell of this layer divides radially by a tangential wall, thus making the layer double; it is these two layers which eventually form the double endodermis so well known in *Equisetum*. Roots of *E. hyemale*, L. were used. The material was hardened with picric acid and dehydrated with absolute alcohol; it was subsequently imbedded in hard paraffin and sections cut with a microtome, the sections being carefully mounted in the order in which they were cut.

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PINUS MONOPHYLLA (Torrey and Fremont).—This is a species which differs from its congeners by its 'solitary glaucous terete leaves' (Sargent). Now, if the leaf were really solitary it would afford an illustration of a terminal leaf, the real existence of which has been denied. It must be remembered, however, that by some botanists the 'needles' of *Pinus* have been considered to be axial not foliar. Whether, however, there is any fundamental difference between axial and foliar structures is still to my mind a matter for doubt, but the point need not here be discussed, as for practical purposes, and especially for the purposes of this communication, I assume that the two are really different. As, moreover, the axial nature of the typical Pine needle is now pretty generally discredited it is not necessary here to allude to the matter further, but as Bertrand¹ considers that the particular species now under discussion is exceptional, and that its 'needle' is really axial, it is advisable to cite what he says about it. 'C'est une sorte de rameau dont le cylindre ligneux s'est ouvert suivant une de ses génératrices, et s'est étalé sur un plan tangent diamétralement opposé à cette génératrice.' Engelm² says 'it was

¹ *Annales des Sciences Naturelles*, sér. 5, Tom. xx (1874), p. 102.

² *Botany of California*, II. (1880), p. 124.

long considered probable that the terete leaf was in reality a connate pair, but the structure shows a single bundle, and therefore a single leaf.'

As it happens that the tree in question often does produce some of its leaves in pairs the probability mentioned by Engelmann did not seem remote, and Sir Joseph Hooker¹ adopted this view, saying that 'the anomaly in the foliage is due to the cohesion of the two semiterete leaves of each sheath by their adjacent faces, and is far from being a constant character. In the plants at Kew the two leaves are as often free as connate; and, on making a transverse section of any connate pair, it will be seen that the vascular bundle traversing the centre of the cylinder is, in fact, double, and that the two parts are sometimes separate.'

In the hope of reconciling the discrepancies between these statements, or of ascertaining which is the more correct, I have recently repeated some observations, which I made first in 1883, both as to the minute anatomy of these leaves and as to their mode of development. These observations are so readily checked, that it will be easy to confute or to confirm the conclusions at which I have arrived.

Alluding in the first place to the anatomy of the single cylindrical leaf, a transverse section through the middle shows that it is really, what it seems to be, a single leaf. The section is circular, the epiderm broken by stomata and consisting of more or less cubical cells, beneath which lies a double layer of thick-walled hypoderm. Close to the hypoderm and each surrounded by a girdle springing from it are the resin canals, two or three in number. Then comes the leaf-substance of several layers of polygonal cells filled with chlorophyll and with abundant starch grains. The outermost of these cells have sinuous walls, while the innermost are straight-walled and radiate in all directions from the bundle-sheath or endoderm. This latter sheath consists of a circle of ellipsoidal colourless cells filled with starch and surrounding the circular (in section) pericycle. The pericycle consists of ordinary colourless parenchymatous tissue, interspersed among which are some relatively very large libriform cells, while in the centre is the vascular bundle proper, in the form of a wide crescentic band, the convexity of which is directed towards the axis, the concavity in the opposite direction. The thick-walled xylem occupies the side nearest to the axis, the thin-walled, but relatively more abundant

¹ Gard. Chron. 1886, July 31, p. 136.

phloëm being on the lower or outer side, a position indicative of the truly foliar nature of the body in question.

On the same shoot with these terete leaves are others arranged in pairs. The transverse section of either of these twin leaves, whether taken in the centre, at the base, or at the apex, shows a nearly semi-circular outline, with the convexity beneath, the concavity above. The pericycle has the same general shape. In all other material points the structure is absolutely the same as in the terete leaves. Sir Joseph Hooker therefore examined a section of a 'connate pair,' and the vascular bundle he saw was really double—one portion belonging to one leaf, one to the other. My observations as to structure agree with those of Bertrand, as illustrated by him¹, and from them it will be seen that (form apart) the structure is in all essentials absolutely the same as in the leaves of other species of *Pinus*. The figure of the leaf-structure of *Pinus Strobus*, given on the same plate by Bertrand (fig. 10), shows how closely similar is the leaf-structure in the two species.

Anatomy then shows that the leaf-like body is a true leaf, which occurs *singly*, but occasionally in pairs. There is of course no difficulty in understanding the latter condition, the anomaly consists in the single cylindrical leaf to all appearance occupying the apex of a shoot. To clear up this anomaly I investigated the development of the constituent parts of the leaf-bud at various stages of growth, and without going into details which are for this purpose unnecessary, I may say that development supplied the clue which neither outward morphology nor internal anatomy sufficed to give. In point of fact, in the earliest stages examined there were always two foliar tubercles, one of which speedily overpassed the other, so that ultimately all traces of the second leaf were obliterated.

The monophyllous sheath of this pine therefore owes its peculiarity to the generally arrested development of one of its two original leaves.

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¹ Loc. cit. tab. ix, figs. 5-6.