there are three cells, and mostly more than one ovule in each cell, though each nut is usually only one-seeded. The ovary of *Juliania* and of *Orthopterygium* invariably contains only one ovule. The flowers and nuts of *Castanea* are collateral, as in *Juliania*. The seeds of both orders are exalbuminous, and the cotyledons are epigaeous in germination.

Weighing the characters in which there is agreement or similarity between the Julianiaceae and the Anacardiaceae, and those in which there is agreement or similarity between the Julianiaceae and the Cupuliferae, the latter in my estimation preponderate; and I cannot suggest a more natural position for the Julianiaceae, in a linear arrangement, than between the Juglandaceae and the Cupuliferae.

W. BOTTING HEMSLEY.

HERBARIUM, ROYAL BOTANIC GARDENS, KEW.

ON THE SEEDLING STRUCTURE OF GYMNOSPERMS¹. *Taxus baccata*.

—The two cotyledons each contain a single collateral bundle, which is, in some cases, slightly mesarch. A section of the axis, taken through the cotyledonary node, shows the central region to be occupied by six plumular bundles arranged in two groups. Each seed-leaf-trace, at its entry into the hypocotyl, has its xylem arranged in a V-like manner, the protoxylem being near the apex, which is pointed outwards. Each cotyledonary bundle travels obliquely downwards, and during its passage the phloem is resolved into two parts. At the same time the metaxylem passes in more quickly than the protoxylem, so that the latter, for a time, is entirely mesarch in position. The phloem masses of the cotyledon bundle fuse with the corresponding tissue of the nearest plumular bundle—the three strands of each group having fused together—and, concurrently, the metaxylem of the same traces moves towards the xylem of the epicotyledonary bundles; hence the protoxylems of the seed-leaves are left in a more exarch position, and, ultimately, are quite exposed. The vascular tissues close up and become more compact, thus a typical diarch root results. It is not possible to distinguish any rotation of the protoxylem: it ultimately occupies an exarch position, because it is left isolated by the movements of the metaxylem. There may be made out, however, an indefinite rearrangement of the protoxylem, coupled with a slight centrifugal movement, after the exarch position has been attained.

Taxus cuspidata, as far as can be ascertained from the study of old seedlings, does not differ in any essential feature from the above species.

Cephalotaxus pedunculata is very similar to *Taxus*. The main points of difference are as follows: (a) The single bundle of each cotyledon shows the mesarch structure more highly developed; and (b) the seed-leaf-traces do not bifurcate so soon. They enter the central region of the axis as well-defined collateral endarch structures, and form a cylinder with the plumular traces, the phloem forming a practically closed

¹ Abstract of paper read before Section K at the York meeting of the British Association, August, 1906.

ring. At a lower level, the bast-circle divides, opposite the cotyledon bundles, into two well-defined masses. During this rearrangement the xylem groups come into contact, the metaxylem derived from the seed-leaves joins up with the plumular xylem, and thus the protoxylem becomes isolated. The subsequent changes are essentially the same as those described for *Taxus*.

Cupressus pisifera, *C. Lawsoniana*, and *Thuja orientalis* all have two cotyledons, each with a single collateral vascular bundle. The transition phenomena are of the same type as in *Taxus*, and result in the formation of a diarch root.

Libocedrus decurrens, also, is similar, but the number of seed-leaves is three, and the primary root is triarch.

Cedrus Deodara.—There are usually eleven or twelve cotyledons; the number, however, varies. Each contains a single collateral endarch bundle throughout its whole length.

Above the cotyledonary node the seed-leaves fuse to form a well-defined tube, the inner surface of which is corrugated; each ridge corresponds to a cotyledon, the foliage leaves of the first node fit into the furrows, and, before the axis is reached, these leaves fuse with the cotyledonary tube. Fusion with the axis takes place, and the general appearance of a transverse section, taken immediately below the cotyledonary node, is that of a monocotyledonous stem. This appearance is, of course, due to the disposition of the leaf-traces of the first three or four nodes; these bundles, however, speedily lose their identity, and, a little later, so also do the vascular strands of the first node. The bundles of the cotyledons now become placed closely together, so that the limits of any one is difficult to determine. At a lower level a gradual change occurs; the phloem groups fuse together in pairs, and, at the same time, the masses of xylem undergo rotation in such a manner that two neighbouring protoxylems become exarch, fuse, and occupy positions alternating with those taken up by the phloem groups. Thus a typical root is formed, usually pentarch or tetrarch.

Abies Firma, *Actinostrobus*, *Callitris*, *Larix*, and some species of *Pinus*, are, on the whole, of the same type.

Pinus Murrayana var. *Sargenti*.—Four cotyledons are usually present: each contains a single bundle which has transfusion tracheids adjoining.

Near the base of the cotyledons the phloem of the bundles bifurcates, and the xylem rotates in such a manner that the protoxylem becomes situated between the two groups of phloem elements. In this condition they enter the axis, and in their passage towards the centre the rearrangement becomes more marked. During the downward course the eight phloem groups fuse in pairs, the metaxylem takes up a position internal to the phloem, and, as the protoxylem is already exarch, a tetrarch root is formed.

There is, however, some variation. Thus another seedling also had four cotyledons, the bundles of three of which exhibited the rearrangement described above while still in the leaf, while the fourth remained undivided throughout its whole course. The central region of the axis being reached, the fourth cotyledonary bundle played the part of a plumular trace, and fused up with the two epicotyledonary bundles situated upon its flanks. The other three seed-leaf strands behaved in the manner already indicated above. Their phloem groups joined with the adjacent bast

of the plumular bundles, and the same applies to their metaxylem elements. A triarch root was thus formed.

Pinus montana var. *gallica*, *P. sylvestris*, *P. Thunbergii*, *P. Gerardiana*, and others all follow a course similar to the above. There is, however, much variation both in the number of the seed-leaves and also in the behaviour of the bundles of the cotyledons.

Tsuga diversifolia may be placed in a position intermediate between the *Taxus* and *Pinus* types.

CONCLUSIONS.

1. A mesarch structure is exhibited in the cotyledonary bundles of *Cephalotaxus*, *Taxus*, and possibly other plants.

2. The Gymnosperms, as a whole, conform to Van Tieghem's type 3 of rotation; there are, however, three varieties of this type: (1), that in which the bundle of the cotyledon is endarch throughout, and the rotation of the protoxylem very indefinite, e.g. *Cephalotaxus*; (2), that in which the seed-leaf-trace is endarch but the rotation of the protoxylem takes place in the hypocotyl, e.g. *Cedrus*; and (3), that in which the rotation of xylem and bifurcation of the phloem of the cotyledonary bundle take place in the seed-leaf, e.g. *Pinus*.

These varieties merge one into the other; it is not possible to draw a definite line of demarcation between them.

3. The numerous cotyledons obtaining in many plants have been formed by the splitting of pre-existing ones. This conclusion is based on the results obtained from the study of many individuals of species with a varying number of seed-leaves.

T. G. HILL and E. de FRAINE.

ON THE SEEDLING STRUCTURE OF CERTAIN CENTROSPERMAE¹.—

NYCTAGINACEAE: *Allionia albida*, Walt.—The petiole of each cotyledon contains a central strand, consisting only of a very few tracheae, derived from one of the bundles of the midrib, and bounded on each side by two normal collateral bundles, the smaller ones being outermost. Near the base of the petiole the traces *a* fuse with the larger bundles *b*. The axis, at the level of the cotyledonary node, contains six plumular strands, which soon fuse together to form two. On the arrival of the seed-leaf bundles into the central cylinder, the groups of tracheae *c* 1 and *c* 2 occupy their isolated positions between the bundles *b* 1, *b* 2, and *b* 3, *b* 4 respectively; while *b* 2, *b* 4, and *b* 1, *b* 3 are separated by the plumular traces *d* 2 and *d* 1 respectively.

Following the hypocotyl downwards, the relations between the bundles are somewhat complicated. *c* 1 and *c* 2 occupy their position throughout, but there is much anastomosing between the bundles of the series *b* and *d*. At the same time the protoxylems of *b* 2, *b* 4, and *b* 1, *b* 3 rotate towards *d* 2 and *d* 1 respectively. This rotation is, however, vacillating, and the rearrangement arrived at may be obliterated

¹ Abstract of paper read before Section K at the York meeting of the British Association, August, 1906.

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