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.

by the formation of a branch passing from b_3 to d_1 , for example. Finally, however, the branching stops, the strands d_1 and d_2 having combined with one of the bundles situated on their flanks, and a definite rotation of the protoxylems b_2 , b_4 , and b_1 , b_3 takes place. The condition now obtaining is that of a tetrarch root; this last movement, however, is too late, for almost immediately the phloem and metaxylem of b_2 , b_4 , and b_1 , b_3 fuse together, enclosing in their meshes the exarch protoxylem which was derived from these same bundles. Thus the groups of tracheids c_1 and c_2 , which have been gradually increasing in number, form the protoxylem of the diarch root.

Mirabilis divaricata, Lowe, follows a similar course.

AMARANTACEAE: *Amaranthus hypochondriacus*, L.—Each cotyledon has a single bundle. Bifurcation of the phloem and the rotation of the xylem towards the exarch position commence some way up the petiole. On the central region of the axis being reached, the rotation of the xylem is seen to be complete, the metaxylem elements speedily pass inwards and, at a lower level, the opposing masses of phloem fuse together. A diarch root is thus formed.

The same changes occur in *A. caudatus*, L.

The transition-phenomena in all the following plants are essentially of the same nature as in *Amaranthus*:—

AIZOACEAE: *Tetragonia expansa*, Murr., *Mesembryanthemum crystallinum*, L.

CARYOPHYLLACEAE: *Corrigiola litoralis*, L., *Lychnis Viscaria*, L., *Polycarpon tetraphyllum*, L., *Silene Otites*, Sm., and *Silene pendula*, L.

PORTULACACEAE: *Portulaca oleracea*, L., *Calandrinia Menziesii*, Torr. et Gray.

CHENOPODIACEAE: *Atriplex hastata*, L., *Chenopodium Bonus-Henricus*, L., *Spinachia oleracea*, L.

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