The Structure of the Starch Layer in the Glossy Petal of Ranunculus.

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With nine Figures in the Text.

INTRODUCTION.

IN a recent paper on the Glossy Petal of Ranunculus (2, p. 742) it was stated that the dense starch layer which lies immediately below the upper epidermis of the glossy part of the petal is apparently more than one cell thick. Only transverse sections of these petals had then been examined, and certainly from the appearance of the layer so viewed it looked as if it were two to three cells deep, as shown in Text-fig. 2 A of that paper (2, p. 741), and in Fig. 1 of this paper. The individual cells vary in size and are not regularly arranged in rows; but are, as it was then expressed, packed together somewhat after the style of crazy pavement.

Longitudinal microtome sections have since revealed the cause of this unusual appearance in transverse section. The starch layer is in fact only one cell thick, but owing to the starch-containing cells being arranged neither at right angles nor parallel, but *obliquely* to the surface of the petal, two or three tiers of these cells, instead of one, are cut in transverse section, thus giving the false appearance of a starch band two to three cells deep.

DEVELOPMENT AND STRUCTURAL FEATURES.

The development of the petal, with special attention to the starch layer, has been followed, chiefly by means of longitudinal sections in four common species of British Buttercups, viz., *Ranunculus Ficaria* L., *R. acris* L., *R. bulbosus* L., and *R. repens* L. This is essentially the same in each except in one surprising difference, not at first obvious, which is described in a later paragraph.

The following details given of the development refer to the petal of *Ranunculus Ficaria*:

Stage 1. In the earliest stage examined the petal had attained a length only of 0·8 mm. A mature petal may be assumed as having a length of 10 to 12 mm. The outline of this young petal, as viewed in

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longitudinal section and magnified × 50 is given in Fig. 2. It is interesting to note that at this early stage the nectary depression *n* and its ventral outgrowth *ns*, destined to become the nectary scale, are quite in evidence. In Fig. 3 the upper part of this petal, taken about the region marked with a cross in Fig. 2, is shown in detail magnified × 150. (For the sake of clearness in this and the five following figures of the same magnification only the cellular contents, viz. nuclei and starch granules of the upper epidermis and starch layer, are shown. For the same reason vascular elements are omitted.) The cells throughout at this early stage are very similar, and are arranged more or less in six layers, two epidermal and four mesophyll. Lower down, where the petal is a little thicker, there may be five mesophyll layers. The uppermost of these, the one immediately below the upper or ventral epidermis, is destined to become the starch layer, *st.* At this stage it shows hardly any differentiation.

Stage 2 (Fig. 4). The petal has lengthened to 3 mm. The ordinary mesophyll cells have begun to elongate in the usual, i. e. the longitudinal, direction. On the other hand, the cells of the starch layer have lengthened somewhat in the opposite direction, viz., at right angles to the surface of the petal. Starch granules have not yet begun to be deposited in them.

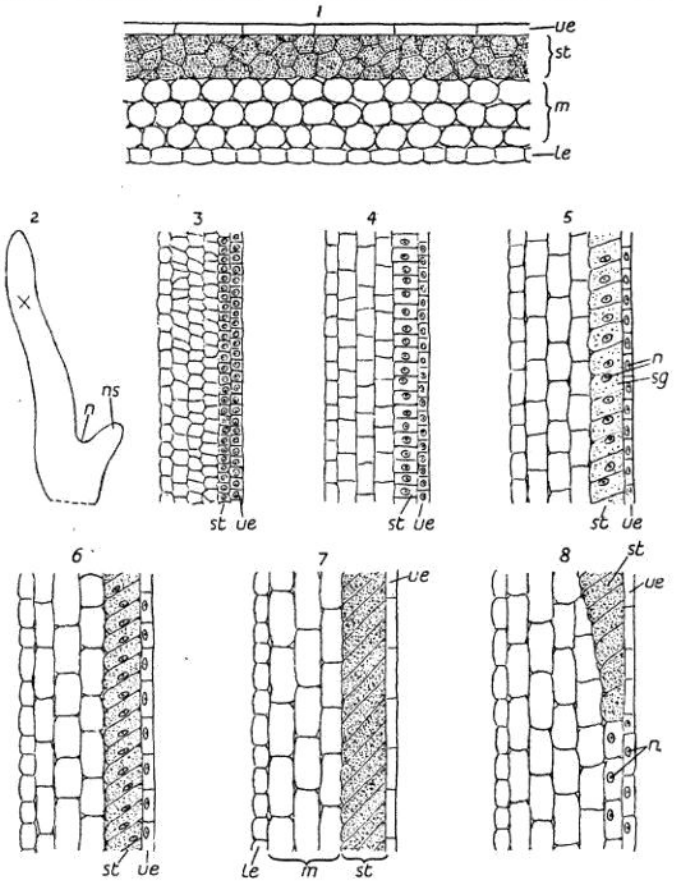
Stage 3 (Fig. 5). The petal is now 5 to 6 mm. long. The cells of the starch layer have commenced to take an oblique direction, and granules of starch, *s.g.*, are now visible in them.

Stage 4 (Fig. 6). Length of petal 7 to 8 mm. A stage shortly before maturity. The oblique character of the starch cells and the starch deposit in them are more apparent. Nuclei are still evident in these cells as well as in the upper epidermis. Though the petal is now deeply yellow it is not yet glossy.

Mature Stage (Fig. 7). The obliquity of the starch cells is considerably accentuated, and the nuclei have disappeared from them. Each cell now consists apparently of a mass of minute starch grains surrounded by a delicate wall of cellulose. The nuclei also, as well as the chromoplasts, have vanished from the upper epidermal cells, leaving them quite hyaline. The petal in consequence assumes its characteristic gloss.

Transition between Gloss and Mat Regions. As pointed out in my former paper (2, p. 740), and by other investigators, the basal parts of these glossy petals are always free both of starch and gloss. In Fig. 8 the transition between the glossy and mat regions in the mature petal of *Ranunculus Ficaria* is shown in longitudinal section. The oblique character of the starch cells gradually becomes less apparent and finally disappears as they become starchless. Nuclei and a few chromoplasts are discernible in both the upper epidermal and sub-epidermal cells of the mat basal region, though absent in the corresponding cells of the glossy part.

Apparently this peculiar oblique structure of the starch layer in the glossy petal of Ranunculus has not been made known before. The only

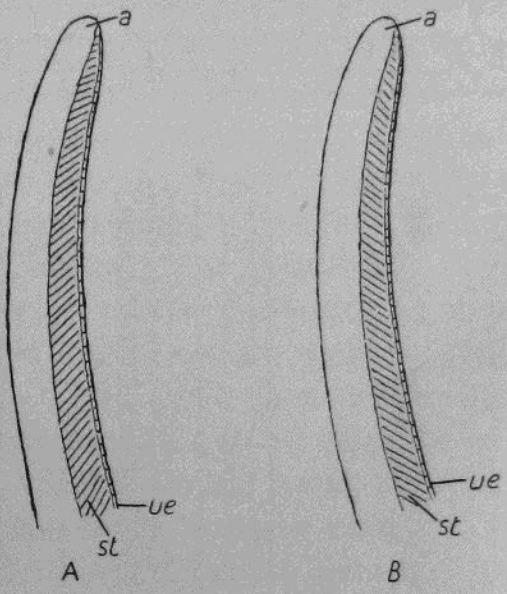


FIGS. 1–8 (semi-diagrammatic), showing the development and structure of the petal of *Ranunculus Ficaria* L. 1. Transverse section of mature petal through the glossy part. Other figures are in longitudinal section. × 150. 2. Outline of the youngest stage examined : *n.*, nectary depression ; *ns.*, outgrowths which become the scale of the nectary. × 50. 3. Part of Fig. 2 (stage (1) of text) taken from the region marked by the cross. × 150. 4. Stage (2) of text. × 150. 5. Stage (3) of text. × 150. 6. Stage (4) of text. × 150. 7. Mature stage. × 150. 8. Shows transition from upper glossy area to mat basal region. × 150. *u.e.*, upper epidermis ; *l.e.*, lower epidermis ; *st.*, starch layer ; *m.*, mesophyll. Cell contents (nuclei, *n.*, and starch granules, *s.g.*) are only indicated for the starch layer and upper epidermis.

drawing of a section of the mature petal of which I am cognisant is a Text-fig. in Köstlin's paper (1. p. 327). In this the starch layer is shown as a regular row of roundish cells below the upper epidermis. It might be guessed as such from a section cut by hand, and that was my impression more or less before using the microtome. The cell walls are very delicate,

and the abundance of starch granules prevent their being seen at all clearly. Their appearance as brought out in transverse and longitudinal sections was entirely unanticipated.

Finding that the longitudinal sections of the petals of *Ranunculus acris*, *R. bulbosus*, and *R. repens* revealed likewise oblique starch cells, one



FIGS. 9 A and 9 B. Diagram (not drawn to scale) of the upper part of the petal in longitudinal section to show the difference in the slope of the starch cells. 9 A. Direction taken by the cells in *Ranunculus Ficaria*. 9 B. Opposite direction taken by the cells in *R. acris*, *R. bulbosus*, and *R. repens*. (*a.*, apex of petal; *st.*, starch cells; *u.e.*, upper epidermis.)

naturally jumped to the conclusion that the structure of the starch layer would be essentially the same in all species of glossy Ranunculus; but doubt was cast upon such a generalization by the following observation.

After making the drawing of the longitudinal section of the mature petal of *Ranunculus Ficaria*, a similar section of one of the other species was being examined when it was noticed that the direction of the slope of the starch cells was the reverse of that represented in the drawing. On referring to the section of *R. Ficaria* it was found that no error of delineation had been committed as one at first imagined; and the unexpected and interesting detail came out that the starch cells in the petals of *R. acris*, *R. bulbosus*, and *R. repens* are sloped in the opposite direction to that in *R. Ficaria*. The diagram (Fig. 9) will make this distinction clear. In *R. Ficaria* the slope of the starch cells is directed downwards, i. e. towards the base of the petal and inwards, i. e. towards its interior. In the other three species the slope is just the opposite, viz., upwards, i. e. towards the apex of the petal and inwards.

COMMENTS.

Since this difference in the obliquity of the starch cells occurs specifically where it might be expected on general grounds of affinity, there is little doubt but that these three common Buttercups, *R. acris*,

R. bulbosus, and *R. repens*, are more closely related to each other than they are individually to *R. Ficaria*—a species which stands considerably apart within the genus.

In view of these two opposite types of obliquity in the starch cells it is difficult to imagine the one changing by a process of reversibility into the other. It seems easier rather to conjecture that from an original layer of starch cells with no obliquity two lines of evolution arose with opposite types of slope. The investigation is being continued with this possibility in view. Already indications of no slope in the starch cells has been observed in some species, notably in a New Zealand one, where primitiveness might be expected. In fact, a preliminary examination of several species of Ranunculus suggests that there may be considerable variation in the structure of the starch layer.

It is hoped, therefore, that the structure of this layer may have value in the working out of a phylogenetic scheme for the genus. At any rate the view already put forward (2, p. 752), that the glossy character of the petal may be of considerable importance in the natural classification of the genus, is strengthened by the discovery of the peculiar structure of the starch layer in these four species.

Acknowledgements.

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Summary.

1. The cells composing the starch layer in the glossy petal of the four species of Ranunculus investigated take an unexpected *oblique* course, thus presenting in transverse section the appearance of a layer two to three cells deep. In reality it is only one cell thick.

2. The development of the starch layer in the petal of *Ranunculus Ficaria* has been followed out in detail.

3. The direction of the slope of the starch cells in *R. acris*, *R. bulbosus*, and *R. repens* runs in the opposite direction to that in *R. Ficaria*. It is probable, therefore, that there may be considerable variety in the structure of the starch layer in the genus.

4. It is suggested that the structure of the starch layer may be of value in working out a phylogenetic scheme for the genus.

Literature cited.

1. Köstlin, H.: Zur physiologischen Anatomie gelber *Ranunculus*-Bluten. Bot. Archiv., Bd. vii, pp. 325–46, 1924.

2. Parkin, J.: The Glossy Petal of Ranunculus. Ann. Bot., xlii, pp. 739–55, 1928.

Page 204. *The last three lines should read:* This difference in the obliquity of the starch cells occurs specifically where it might be expected on general grounds of affinity, since there is little doubt but that . . .