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DEVELOPMENT OF A DANDELION FLOWER.

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THERE are several reasons why the organogeny of flowers should be carefully studied, not the least of which is, that it reveals genetic relationships and could be made to read the riddle of many a puzzling affinity. This paper is based upon some very careful observations made during the present year, undertaken especially for the purpose of investigating the development of an inferior ovary, of syngenesious anthers, and of obtaining any possible evidence in reference to any of the contending theories of the morphology of the ovule. It is not the intention to discuss the various relationships indicated by the different phases in the development of the dandelion flower, though that might help determine relative rank, for this would necessitate a wider range of observation than the subject has received from any one, but simply to give an illustration of such work and to indicate what this specific case teaches with reference to the three subjects just mentioned.

Embryology assures us that the most essential characters make their appearance first, and that the order of development is from general to specific. If such a law can find its application in the development of a flower, there can be no deeper-seated distinction between groups of flowers than that of inferior or superior ovary, for it is the very first character to make its appearance. Of course the embryology of the plant begins far back of the flower, in the seed, where the development of one or two cotyledons indicates probably the first natural division of seed-bearing plants.

[1] Read in Section F of the A. A. A. S. at Minneapolis, Aug., 1883.

With this division confirmed in the structure of the stem and leaf, we approach the development of the flower as the first index of subdivisions. We are in the habit of making these subdivisions in the group of dicotyledons upon the basis of petals distinct, united or wanting; when in order of development this distinction appears immediately after that of inferior or superior ovary.

Turning now to the specific case of the dandelion, we find that the first structure which stands for each flower is a broadly obconical mass, very flat and very smooth upon its upper surface (Fig. 1 *a*).

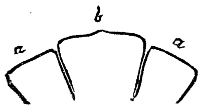

FIG. 1.

This represents the broadened extremity of the lateral axis which is to bear the flower, and thus far the developmental path pursued by flowers with inferior and those with superior ovaries is the same. At the next step, however, which is really the first step in the development of true floral organs, the path divides, and in the case before us the apical cells cease to grow and all further axial development is completely suppressed. The peripheral cells of our obconical mass, however, continue to develop, and almost immediately five points of especially rapid growth are detected, which make the upper edge of the rising ring faintly five-lobed (Fig. 1 *b*). This ring continues to develop until the whole structure has assumed the appearance of a cup, with very thick bottom and scolloped rim (Fig. 2).

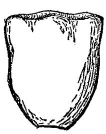
FIG. 2.

This cup continues to elongate and hence deepen, the rim becoming more and more decidedly five-lobed, when presently a shallow horizontal constriction begins to appear (Fig. 3), dividing the whole mass at first into two equal divisions and first distinguishing the corolla above from the ovary below. This line of division forms an apparent node, and from this, without and within, appear in succession all the other floral organs.

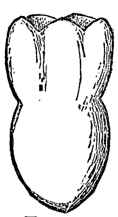
FIG. 3.

The node is only an apparent one, for the floral organs do not have their real origin there, although, in the language of systematic botany, such would be called their insertion. If this insertion, however, is the real origin, the order of development is both acropetal and basipetal, for, beginning with the corolla, we have the andrœcium and gynœcium appearing in acropetal succession, and finally the calyx. The only inference is, that all four of the floral organs are blended together in the primitive ring which rises from the original obconical mass, that they are all essentially hypogynous, and that their separate appearance at the so-called node is simply a freeing of their upper extremities. In this case the real order of development remains acropetal, and the apparent late appearance of the calyx due only to the late development of its upper portions.

Simultaneously with this constriction two other changes take place. The tips of the petals begin to turn inwards and become thickened, until finally their backs almost meet, thus furnishing a close protection about the nascent organs within (Fig. 4 *a*). Looking down upon the mouth of the corolla tube at this stage, there is a striking resemblance to a coral cell, and this likeness is intensified by the flowers being massed together upon a broad receptacle. Then for the first time can it be noted that the contiguous edges of the two inner petals are simply in contact but not united, except at the very tip, and that the tube enclosing the essential organs is a slit one. This slit extends almost to the constriction or base of the corolla, the extremely short portion of complete tube below representing what in anthesis is to become the true tube; while the slit tube investing the essential organs is to become the strap. In the bud state, therefore, it is the strap that protects the stamens for almost their entire length, strap and stamens elongating *pari passu.* But during anthesis a wonderfully rapid development of the true tube carries the strap part far above the stamens. During this rapid pushing upward, the slit begins to widen from below, the tips of the two inner petals being the last to separate, until finally the flat strap of the completely open flower appears. So rapid is this pushing upward of the true tube, that one whorl of flowers may have it fully developed while the whorl next within will have no indication of its growth.[1]

Having thus traced the corolla in its development, we will consider a second and more important change which appears simultaneously with the constriction that marks out ovary and corolla tube. It has been said that this constriction forms an apparent node at which all the parts subsequently appear. Almost as soon as the node is seen there appear within five small protuberances, which develop rapidly, become oblong, and are soon distinguished

[1] Just here is an interesting resemblance of the corolla tube in both origin and function, to the filament. For the stamens almost fully mature before the filament elongates, which is done often with great rapidity.

as the forming stamens (Fig. 4 *b*). These stamens remain perfectly distinct until quite late in the history of the bud, when they have become very much elongated. Then the edges of the anthers, coming in contact, begin to cling; the union appears to become firmer and firmer, until it takes quite a pull to separate them. The union, however, is only apparent, for careful cross-sections show close contact between incurved edges, incurved as if by being pressed firmly together, but no blending of tissues. The two contiguous epidermal layers are continuous and complete. (Fig. 5).

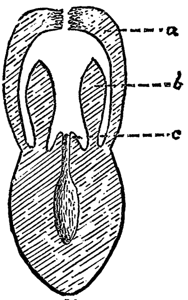

FIG. 4.

To complete the account of the development of the stamens, mention should be made of the pollen grains. As soon as the anther cells begin to elongate, exchanging their broadly oval outline for one that is narrower and finally linear, it is easy to detect within them tolerably well-defined rows of large, squarish mother-cells, about two rows in each half of the anther. As the growth proceeds the contents of these mother-cells are seen to pass through the well-known stages in the development of four pollen grains in each. The pollen grains, when first freed from the mother-cell, are roundish, but when the hairs begin to appear upon the style, they become quite angular, generally six-angled in outline. A close inspection shows that this angular appearance is due to the beginning development of the wings, which gradually lengthen, broaden and become dentate, until the mature pollen grains very closely resemble those of Cichorium, so commonly figured.


FIG. 5.

The third organ to make its appearance is the pistil. When the stamens have become oval masses and are just beginning to constrict below into short, broad filaments, just within the stamineal circle, there arise, at the so-called node, two outgrowths upon opposite sides. Below the node, within, there is yet quite a cavity, and the two outgrowths rapidly develop towards each other, overarching the cavity below, and presently meet in the center, when they resemble two lips (Fig. 4 *c*). These lips grow together, forming the style, and then elongate, soon becoming a little longer than the stamens. In the meantime the cavity below is being constricted from above downward, until the once oval cavity has become flask-shaped, and the neck of the flask closed up, leaving the cavity of the ovary some distance below the base of the style. It is at this stage that all the parts begin to elongate rapidly, and the swelling appears at the bottom of the ovary-cell which is to become the ovule, and then also the calyx appears in the form of minute scales, which develop into the long hairs known as pappus. Thus the apparent sequence in the development of the four floral organs is corolla, andrœcium, gynœcium, calyx; but of necessity the calyx is the oldest, though the part called pappus is the last to appear. It was attempted in vain to detect in the primitive ring, or later in the wall of the ovary, any evidence of the blending of two or more distinct parts. No such indications could be found, and the inference that all four floral organs are represented in the wall of this inferior ovary rests, not so much upon the structure of the wall as upon the order of succession in the appearance of the floral organs. The idea that this primitive ring really belongs to the receptacle, and that the node, so-called for convenience, is in reality a node, would be tenable in this case but for two reasons, viz., the late appearance of the calyx and the fact that the corolla-lobes appear, not after the ring but with it, indicating that it in reality belongs to the floral organs.

It remains yet to speak of the ovule and the support it furnishes to any of the existing theories.

The ovule appears not exactly at the bottom of the ovary-cell, but a little to one side. By carefully tracing the fibro-vascular bundles, it was found that the axial bundle belonging to the pedicel of the flower ended abruptly at the bottom of the cavity of the ovary, sometimes rising into it as a small convexity, representing the real *punctum vegetationis* of the flower bud, the checking of whose growth determined the character of an inferior ovary. Just beneath this terminal point two lateral fibro-vascular bundles arise and run up each side of the carpellary wall. From one of these lateral bundles, very close to its origin, a branch arises which enters the funiculus (Fig. 6). In this case, therefore, the fibro-vascular bundle which reaches the ovule is a branch arising from a lateral outgrowth from the axial bundle. An attempt was made to determine whether the nucleus of the ovule was a terminal or lateral growth on the funiculus. Both Grigorieff and Sachs, in researches on Compositæ, and Cramer in other forms, claim that the nucleus is a lateral growth on the funiculus,

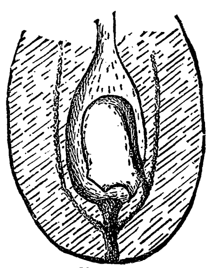

Fig. 6.

but our dandelion could not be made clearly to show it. As for the ovule itself in this case being a lateral outgrowth on the floral axis, there can be no question. At present two general views are held as to the morphology of ovules. Robert Brown, Van Tieghem, Celakovsky and Warming, sustained by Dr. Gray,[1] maintain that the "ovules are productions of and borne upon leaves," and this without exception. Bessey[2] carries this view to an extreme in classing ovules under trichomes, which they surely cannot be if we restrict trichomes to epidermal outgrowths, yet the glandular hairs of Drosera contain a fibro-vascular bundle. The ovules of Orchideæ are the only ones with which I am acquainted in which the funiculus contains no fibro-vascular bundle, and hence could be referred to trichomes, just as the sporangia of ferns.

The second view of the morphology of the ovule, the one held by Magnus, Rohrbach, Hanstein, Schmitz and sustained by Sachs,[3] is that the ovule has different morphological significance, "according to its mode of origin and position." According to this view ovules are produced either on leaves (carpellary) or the axis. To the latter origin are referred all those ovules which are strictly terminal structures of the floral axis, as those of Typhaceæ and Naiadeæ, and also those which arise as lateral appendages of the axis. To his lateral division of ovules produced on the axis, Sachs would refer those of our dandelion and all Compositæ. The two views, therefore, are in accord in certain cases, and at variance in others, and the species under consideration is of the latter kind. It would be interesting then, if possible, to determine whether the ovule of the dandelion is an outgrowth on a leaf, or an outgrowth directly from the axis. If it is the latter, it is either a branch, and its parts the homologues of leaves, which their order of development disproves, or it is itself a leaf and becomes the homologue of the other flower parts. In the case of the dandelion it seems impossible that the ovule can be considered to be produced on the axis as a lateral outgrowth. If the fibro-vascular bundle from the axis led directly into the funiculus such a view might be tenable, but it extends upwards along the carpellary wall, and sends out a branch to the funiculus. The real lateral outgrowths on the axis then, as indicated by the two lateral fibro-vascular bundles, are the two carpellary walls, which

[1] Gray's Text Book, p. 267.

[2] Bessey's Botany, p. 137.

[3] Sachs' Text-book, p. 504.

thus become leaves and the homologues of the other floral organs. It is most likely that the branch which runs up each carpellary wall corresponds to the midrib of the leaf. If so, in this case one midrib produces an ovule, while the other does not, nor do the margins of the carpellary leaves.

To sum up, in conclusion, the testimony of the dandelion:

I. The inferior ovary is produced by an arrest in the development of the floral axis, the rising in a peripheral ring of the floral organs, and the gradual arching over of the cavity thus produced, by the carpellary leaves.

II. The syngenesious anthers are united by contact and pressure, but in no sense structurally.

III. The ovule is not produced directly from the axis, but is an outgrowth from the surface (probably the midrib) of a carpellary leaf.

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NOTES ON THE CHÆTONOTUS LARUS.

BY PROFESSOR C. H. FERNALD.

IN the year 1874, I spent some time in the study of microscopic forms occurring in the fresh-water streams and ponds in and about Orono, Me. Among the animals observed was one which occurs here in considerable abundance, which I suppose to be *Chætonotus larus* Ehr.

The descriptions and figures of this animal given by Ehrenberg, Dujardin and in the third edition of the Micrographic Dictionary, are superficial and unsatisfactory. To gain a more complete insight into the structure of this organism, I spent some time in the study of its anatomy and habits.

Chætonotus larus Ehr., is very common in the fine débris over the bottom of ponds, streams and springs, as well as in decomposing vegetable matters in watering troughs, and in cisterns which have no filters. I have found it at all seasons of the year, even in midwinter in springs which were frozen over.

These animals are about $\frac{1}{225}$ of an inch long, oblong, rounded above, somewhat enlarged posteriorly, and armed on their upper surface with spines curving backward, those on the posterior part being the largest. The under surface is flat and without spines, but has four longitudinal bands of cilia. Upon the head are four colorless eyes, or what appear to be eyes, and also four clusters