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On Elaioplasts.

BY

RUDOLF BEER, B.Sc., F.L.S.

With Plate IV.

IN 1888 Wakker (1) described the occurrence of a conspicuous body lying in the epidermal cells of the leaves and in the superficial tissues of the root and stem of Vanilla planifolia. This body is somewhat larger than the nucleus and considerably larger than the amyloplasts; it possesses a sharply-defined outline and a peculiar, somewhat yellowish colour. In each plate-like epidermal cell one such body occurs, and it often lies near the nucleus, although in other cases it may occupy a different position in the cell. As this body consists of protoplasmic material and contains oil, Wakker named it Elaioplast, or oil-former.

He made a careful study of the effect of reagents upon the elaioplast, and briefly described the gradual disappearance of these bodies in older cells. Walkler was unable to study the origin of the elaioplasts as he had no suitable material for this purpose. He found elaioplasts also to occur in the cells of another species of Vanilla, known to him under the name of Vanilla aromatica latifolia. In 1893 Zimmermann (2) found similar bodies to occur in Funkia coerulia, F. lancifolia, F. Sieboldiana, Dracaena sp., Ornithogalum scilloides, Agave americana, A. Mitis, and in Oncidium snave.

Raciborski (3) in the same year described elaioplasts in the tissues of various species of *Ornithogalum*, *Albuca*, *Funkia*, and *Gagea*.

Zimmermann further found these bodies in the internal cells of the stem of *Psilotum*, and in the perianth leaves of *Maxillaria picta*. The shape of the elaioplasts differs in various plants, but it is usually constant in the same species. Spherical forms, grape-like bodies, irregular plasmodium-like masses, have all been described.

Usually only one elaioplast occurs in a cell, but in some cases they may be more numerous (e. g. Ornithogalum). The finer structure of the elaioplast has been carefully examined both by Zimmermann and by Raciborski. It has a finely granular appearance due to the occurrence of a number of tiny, highly refractive spherical bodies lying in its substance. One or more less refractive spots often occur within the elaioplast. The elaioplasts of

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the species of *Gagea* are said by Raciborski to possess a somewhat different structure. In these plants the spherical elaioplasts are characterized by the feeble development of the stroma; they are surrounded by a plasmatic envelope and contain within this an oily substance like that found in other elaioplasts. The micro-chemical observations of Wakker and Zimmerman have shown that the elaioplasts consist of a plasmatic matrix or stroma in which are embedded numerous minute oil drops. Zimmermann points out that these oil drops show a close similarity in their reactions with the oil drops obtained from plastids.

The origin of the elaioplasts has been very little studied. Raciborski states that in *Ornithogalum umbellatum* they arise as small, highly refractive spherules which always lie at one pole of the usually elongated cell-nucleus.

Although Wakker had no material with which to work out the development of the elaioplast, he ventures an interesting suggestion at the conclusion of his account of the oil-bodies of liverworts. 'Leider ist durch diese Mittheilung der Ursprung der Elaioplasten nicht ausgemacht, es ist mir aber äusserst wahrscheinlich, dass es bei den Lebermoosen metamorphosirte Chlorophyllkörner sind. Vielleicht ist dieses auch bei Vanilla der Fall.'

Garjeanne's work (5) on the oil-bodies of the Jungermanniales clearly indicates that these bodies have a different origin to that suggested by Wakker; my own observations on elaioplasts recorded below will however, show that his guess was nearer the truth in the case of some Phanerogamic elaioplasts.

The function of the elaioplast is quite unknown. Wakker believed that they might be oil-formers much as leucoplasts are starch-formers. Zimmermann offered the suggestion that they might prove to be parasitic or symbiotic fungi living within the cells of the higher plant.

Raciborski, however, considers them to be normal organs of the cell in which they occur, and classes them with oil-bodies, tannin-vesicles, and ordinary vacuoles.

In the liverworts oil-bodies have been known to occur since the time of Gottsche, and even earlier. The first really fundamental description of these bodies is due to Pfeffer (4), and quite recently their development has been fully worked out by Garjeanne (5). Oil or fat bodies of a somewhat similar appearance to those of the liverworts have been described by Radlkofer (6 and 7), Monteverde (8), Solereder (9), and others, in the tissues of a number of Dicotyledons and Monocotyledons. Opinion varies very much as to the relation of these oil-bodies of liverworts and Phanerogams to the elaioplasts. Some believe the two structures to be closely allied, whilst others are of opinion that they are radically different from one another.

From this brief survey of the literature it will be seen that elaioplasts,

corresponding to those discovered by Wakker in *Vanilla*, have up to the present been found only in Monocotyledons, with the single exception of *Psilotum* reported by Zimmermann.

Moreover, apart from a few quite insufficient observations we are still entirely in the dark regarding their true nature, their significance, their origin, and their fate.

During some observations upon the pollen-grains of Compositae I was interested to find bodies which resembled the Monocotyledonous claioplasts occurring in the tissues of the floral region of Gaillardia Lorenziana 1.

This would extend the distribution of elaioplasts to a member of the Dicotyledons.

My first endeavour was to make sure that I was dealing with true elaioplasts. In the hairs upon the corolla of young flowers, where I first observed these bodies, they occur as more or less spherical, highly refractive, granular structures usually somewhat larger than the nucleus, and in most cases lying singly in a cell, although two or even more such bodies were occasionally met with.

Their reactions were found to be as follows:-

 Heated gently upon the slide (whilst lying in a physiological salt solution), drops of oil are exuded from their surface (Fig. 13).

2. Osmic acid (as this occurs in Flemming's stronger solution) turns them black or brown.

 Potassium bichromate after twenty-four hours action leaves them quite colourless, but causes the extrusion of oil globules as in 1.

4. Alkannin solution in 60 per cent. alcohol colours the bodies deeply red.

Iodine (in K1) colours them brown and causes the extrusion of oilglobules (Fig. 12).

Absolute alcohol dissolves out the oil from their interior and leaves them vacuolated.

7. In strong HNO₃ (warmed), followed by NH₃, they give the Xanthoproteic reaction (viz., deep yellow coloration).

 Glacial acetic acid after twenty-four hours' action causes great extrusion of oil drops but no solution.

9. 10 per cent. KOH. after twenty-four hours' action dissolves neither stroma nor oil drops.

These reactions, combined with their general appearance, show that the bodies occurring in the hairs of Gaillardia are in all respects similar to the elaioplasts described by previous authors.

In very young hairs from capitula which were still quite small and

¹ Gaillardia Lorenziana is a German variety of G. picta, which itself appears to be only a garden variety of G. pulchella. I have not yet had an opportunity of examining any other form or species of Gaillardia except the one mentioned above.

immature and entirely enclosed within the involucral bracts, no elaioplasts were yet to be seen. The cell contained a nucleus and cytoplasm which partly formed a peripheral layer and partly extended in strands and bars through the cell cavity (Figs. 1 and 2). Embedded in the cytoplasm was a number of small, highly refractive grains which had all the appearances of ordinary leucoplasts. That these refractive grains are really leucoplasts is confirmed by two facts.

Firstly, the resemblance between the unquestionable, starch-forming leucoplasts occurring, for example, in the hairs which cover the very young leaves, and the highly refractive grains contained in the corolla-hairs, is complete, although starch is not found in the latter under the usual

conditions of growth.

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Secondly, if the enveloping bracts be removed from a young inflorescence without detaching it from the parent plant, and the corolla-hairs exposed to a strong insolation, starch can be seen to have developed in some of these refractive grains.

For these reasons I believe the highly refractive grains occurring in the cells of the corolla-hairs to be leucoplasts, some of which, however, may

have lost the power of starch-formation.

In somewhat older hairs these plastids, a number of which show signs of undergoing degeneration, tend to aggregate together at one or more spots within the cell. Not infrequently this aggregation of the plastids is in the neighbourhood of the nucleus, but in many instances it is found to occur at other regions of the cell (Figs. 3 and 4).

At first the aggregation of the refractive grains is a very loose one, but it gradually grows closer and closer (Fig. 5) until the compact, highly refractive bodies are formed, which we have already recognized as elaioplasts (Figs. 6, 7, and 8). The elaioplasts in the corolla-hairs of Gaillardia are, therefore, formed by the aggregation of plastids and their degeneration products at one or more spots in the cell. Within the claioplast the plastids soon appear to undergo further degeneration with the production of an oily material. That Zimmermann should find a close similarity between the oil of the elaioplasts studied by him and the oil obtained from plastids is no longer surprising.

All the plastids of the cell have not clumped together within the elaioplast. A certain proportion still remain scattered through the cell

(Fig. 7).

For some time there is little alteration within the cell. The conspicuous elaioplast may lie in almost any part of the cell, but often it takes up a position near the nucleus. In some instances it entirely envelops the nucleus, as I have represented in Fig. 8.

In much older hairs we find the elaioplast undergoing a change. Its outline becomes less regular, and in some cases it becomes drawn out and elongated in form (Fig. o). In favourable cases one can see that the faintly yellowish drops or granules of which it now chiefly consists are becoming detached from the periphery of the main body of the elaioplast, and that these drops or granules are gradually scattered through the cell cavity (Fig. 10). Here they deepen their yellow tint, and in association with the red pigment developed in the cell-sap they produce the yellow, orange, or red coloration of the mature corolla-hairs, according as the one or the other pigmenting material predominates (Fig. 11).

The constituent plastids of these elaioplasts, therefore, undergo quite a similar series of changes as the chlorophyll grains in autumn leaves, which were first described in detail by Sachs in 1863 (10), or in ripening fruits, also studied by Sachs (1865). By the time the hairs are fully matured the elaioplast has entirely resolved itself into the scattered yellow pigment of

the cell.

The corolla-hairs are not the only place in which elaioplasts occur in Gaillardia. They are also to be found in the stigmatic hairs, or in the more internal cells of the stigma and of the style, in the vegetative cells of the anther, and in the cells of the young pappus (calyx).

I sought for them in vain in the root-hairs or in the tissues of the root, in the leaf and the hairs which cover it, in the stem, and its clothing

of hairs.

After I had completed my observations on the elajoplasts in the corolla-hairs, and drawn from them the conclusions which I have expressed above, I received a beautiful confirmation of the correctness of these views from the study of the elaioplasts in the other floral regions of Gaillardia.

In the cells of the connective of the young stamen, bodies occur which resemble the elaioplasts of the corolla-hairs in every respect except that they are coloured more or less deeply green. They are mostly spherical, although sometimes elongated in shape (Fig. 14). Moreover, in neighbouring cells of the connective we find every transition between deeply green bodies of this description, and others which are almost colourless and differ in no way from the elaioplasts of the corolla-hairs. On the addition of Iodine solution the occurrence of starch within the green bodies is readily demonstrated (Fig. 12). After remaining in the Iodine solution for some hours these intensely black-stained bodies form a most conspicuous feature in the otherwise yellow cells.

The appearance and reactions of these green bodies, no less than the transitions which occur between them and the ordinary elaioplasts, leave no doubt that they also are elaioplasts which contain chlorophyll, and which have retained the power of starch-formation. The cells of the young style and stigma also possess green, starch-producing elaioplasts.

Another very interesting case of green elaioplasts is furnished by the cells of the flattened basal plates or wings of the young pappus. In many of these cells scattered chloroplasts occur, arranged as in ordinary assimilating tissue (Fig. 15). These chloroplasts are large, and many of them contain droplets of an apparently oily nature embedded within their substance. Probably these oil-drops mark the first stage of degeneration, although the power of starch-formation has not yet been lost. I was at first inclined to believe that the oily drops within these chlorophyll corpuscles represented the normal grana of these bodies developed to a rather unusual extent. The fact, however, that the chloroplasts of the other organs of Gaillardia (e.g., of the leaf) do not show any distinct grana of this kind, coupled with the further fact that the chlorophyll bodies of the pappus soon show undoubted signs of degeneration, has led me to conclude that the oil-drops are associated with the degradation of these chloroplasts.

In other cells of the pappus-plates the chlorophyll corpuscles tend to hang, more or less loosely, together. In yet other cells the aggregation of the chloroplasts is closer, although the outlines of each separate plastid is still maintained (Fig. 16). A further step in this aggregation of the chlorophyll bodies is seen in other, neighbouring cells in which they become so closely clumped together that the outlines of the individual chloroplasts can no longer be distinguished, and we obtain a typical green elaioplast in which the oil-drops of the plastids produce the finely granular appearance characteristic of these structures.

All these stages may be observed in adjoining cells of one and the same pappus-plate. They are best studied at about the time when the young pollen-grains are still without a membrane of their own and are enveloped in the special-wall (special mother-cell stage).

In older pappus-plates the green colour of the elaioplasts gives place to yellow, and other degeneration processes become evident.

Now that the development of the elaioplast has been followed in at least one species we are in a better position to compare this body with the oil-bodies of Hepaticae. Wakker evidently believed in the identity of the two structures, whilst other authors—such as Von Küster (11)—held an opposite opinion. On comparing what has been written above regarding the elaioplasts of Gaillardia with Garjeanne's careful account of the development of the oil-bodies of several Jungermanniales, it will be seen that the two structures have a very different origin. In the latter the oil-bodies arise as vacuoles in the cytoplasm, whilst we have seen that the elaioplasts of Gaillardia are formed by the aggregation of plastids and their degeneration products. Whilst, therefore, we cannot draw general conclusions until other species have been examined more fully, we may say that the developmental history of the elaioplasts of Gaillardia is essentially different from that of the oil-bodies of the Hepaticae.

External conditions seem to exert very little influence on the appearance of the elaioplasts.

I have kept the young capitula in total darkness for several (3-6) days without altering the development or structure of the elaioplasts of the corollahairs in the least.

The only deviation which I have ever found in the behaviour of the plastids of the corolla-hairs occurred in a very young capitulum from which the protecting bracts had been dissected away so that the tiny flower-buds were exposed to the full effect of the light.

Here the aggregation of the plastids into elaioplasts had been retarded in a number of cells.

The clumping together of the plastids of a cell into a more or less close mass is by no means an unusual occurrence. Kraus (12) many years ago described the effect of cold upon the chlorophyll-grains of winter leaves. Here these bodies were found to have passed from the walls to the interior of the cells and were there aggregated in clumps. Charles Darwin (13), in 1882, observed a very close massing of the chloroplasts in the cells of certain insectivorous plants under the influence of ammonium carbonate (a solution of 4–7 parts of ammonium carbonate in 1,000 parts water).

The work of Stahl (14), as well as of others, has shown that an irregular aggregation of chloroplasts is produced under the influence of intense illumination.

Pfeffer (15) mentions that similar results are induced by injuries and various mechanical agencies.

The close massing of the plastids into compact elaioplasts is most probably connected with their degeneration, and may very likely be compared to the aggregation of these bodies produced by the injurious agencies enumerated above. That the elaioplasts have any particular function to perform which is of direct significance to the life of the cell is most unlikely.

A secondary use for the degeneration products of the plastids—massed into elaioplasts—certainly does occur in the case of the corolla-hairs of *Gaillardia*, for here they give rise to the yellow pigment which forms an important part of the attractive apparatus of the mature flower.

In other situations, however, the elaioplasts seem to disappear, without having even this secondary biological significance.

It will be interesting to examine the Monocotyledonous elaioplasts again more closely in the light of what has been learnt of these bodies in *Gaillardia*, to see whether they possess the same nature and history. I hope to obtain material for this purpose during the next season.

In conclusion, I must express my indebtedness to a Government grant for assistance in carrying out this research.

SUMMARY.

 Elaioplasts which hitherto had only been met with in Monocotyledons (and Psilotum) have now been found to occur in a Dicotyledon—Gaillardia.

 The claioplasts occurring in the corolla-hairs of Gaillardia are found to agree in their appearance and in their reactions with the elaioplasts described by Wakker and Zimmermann in Monocotyledons.

3. They have been found in the corolla-hairs, the pappus, the connective of the stamens, the style and the stigma of *Gaillardia*. They are absent from the tissues of the stem, the root, and the leaf of this plant.

 They are formed by the aggregation of plastids and their degeneration products at one or more spots in the cell.

5. In the corolla-hairs of *Gaillardia* they give rise to the oily, yellow pigment which, in association with the red cell-sap, gives the mature hairs of the flower their characteristic colour.

6. The elaioplasts occurring in the stamens and in the style and stigma of *Gaillardia* agree in all respects with those of the corolla-hairs except that they are coloured green with chlorophyll, and can form starch within their substance. In neighbouring cells of these tissues all transitions occur between elajoplasts, which are coloured brightly green, and those which are

almost colourless like those of the corolla-hairs.

In the tissues of the young pappus every transition can be found in neighbouring cells between those which contain scattered chloroplasts entirely free from one another, and those in which the chloroplasts have clumped together to form a green mass identical with the green elaioplast of the stamen or the stigma.

8. The elaioplasts of *Gaillardia* (and *probably* of the Monocotyledons also) differ essentially in their development from the oil-bodies of the liverworts.

9. External conditions were found to exert very little influence upon the appearance of the elaioplast, although rather strong, direct illumination seemed in one case to have somewhat retarded the aggregation of the plastids.

10. The close massing of the plastids into compact elaioplasts is probably connected with their degeneration, and may be compared to the aggregation of the plastids under the influence of various (mostly injurious) agencies described by several previous writers.

11. It is most unlikely that the elaioplasts perform any function of direct importance to the life of the plant, although they may in some cases (corolla-hairs of *Gaillardia*) serve a secondary, biological purpose.

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EXPLANATION OF FIGURES IN PLATE IV.

Illustrating Mr. Beer's Paper on Elaioplasts.

All the figures refer to tissues of Gaillardia Lorenziana. Preparations examined and drawn in 6 per cent. NaCl solution unless otherwise stated.

Fig. 1. Very young cell of corolla-hair before elaioplasts have developed. Leucoplasts distributed in the cytoplasm. × 1075.

- Fig. 2. Apex of another corolla-hair showing scattered leucoplasts. x 650.
- Fig. 3. Young cell of corolla-hair showing an early stage in the aggregation of plastids. × 650.
- Fig. 4. Corolla-hair showing a stage in aggregation of plastids. × 650.
- Fig. 5. Corolla-hair with later stage of elaioplast development. × 650. Figs. 6, 7, 8. Elaioplast completely developed in corolla-hairs. × 650.
- Fig. 9. Cell from older corolla-hair. Elaioplast elongated and showing first indication of disintegrating. × 650.

Fig. 10. Later stage; substance of elaioplast becoming distributed through the cell. x 600. Fig. 11. Mature corolla-hair. Yellow pigment-material derived from elaioplast completely distributed through the cell. × 650.

Fig. 12. Green elaioplast from anther after two days in dilute Iodine solution. Oil-drops have been exuded at the surface. Starch (shown in the figure as black grains) contained in the yellowstained matrix. x 600.

Fig. 13. Elaioplast from corolla-hair in -6 per cent. NaCl after gently warming on slide over spirit-lamp. x 650.

Figs. 15 and 16. Two neighbouring cells from plate of pappus. In Fig. 15 the chloroplasts are scattered, whilst in Fig. 16 they are massed into a loose clump. Note oil-drops within the chloroplasts (represented as black dots). x about 600.

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BEER - ELAIOPLASTS

By Rudolf Beer BSc. F. L.S.

In 1888 Wakker described the occurrence of a conspicuous body lying in the Epidermal cells, of the leaves + in the superficial tennes of the e roll of Stem of Vanilla planifolia. This body is Smeathat larger to the uncleus + considerably larger than the ampliphasts; it prosesses a sheeffed defined online & a peculiar, about yellowish colour. In Each plate-like Epidema all one Such body occurs to it after his there the Hundred the Hundred tutal to the potential of the his a different position in the cell. as this body consists of protoplasmic material of contains oil Wakker proposed to haved it Elacoplast or oil - former. He also found Plaioplasts to occur is another species of Vanilla vig one know Vanilla aromatica Catifolia. He He made a careful study of light of realist upon the claimplast of the bribes the gradual disappearance in older cells. These

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been definitely track. The function of the clarisplant is quite unknown. Wakker believed they might be oil - formers unch as plastide lucaplastides are Starch - formers. Lemmerman Succession offered the suggestion that they might sports he para sitie or symbiotic fungi living within the cells of the higher plant. Rauborski , however, considers them the normal organs of the cell shiel contains them and by Hunt Institute for Botanical Documentation of classes them with oil bodies tannin. Vesicles + ordinary Vacuoles. to the leverworts oil-brokes have been known to occur since the time of Gottsche & suen Earlier. They were final described in detail of Holde The first really fundamental description of these bodies is due to Pfeffer & quite recently their development has been fully worked out & Farjeanne (5). Opinion her Kare Dil or fat bodies of a Somewhat Similar

to those of the lineworth appearance have been described by Radlkofer (5) Monteverde (8), Solvedor (9) + others in the troscus of a number of the Dicotylesons or Monocotylesons. Opinion ber remode very much as to the relation of these sil-bodies of horrorts o Phanerofans to the Elaiophots of Some believe the two Structures to be observed police whilst are of opinion that they are of grant a different In p. 458 of the work on the oil bodies of Dig Tiz fungermannialistute For Botan Harry punentut occurs & Sentence which is of Considerable interest in the light of olyt is to follow in the present paper Harston in referring to Wakkins claiplants he says These oils formers or Elaiplants are generally to be found in the neighbourhood of the under or agree inder in then young state agree in desiral respects with leufablasts". He ruters into no delails bourne,

From this brief survey of the literature it will be Seen that slaiplasts corresponding to those discovered by Wakker in Vanilla have up to the present been found only in Monocolyterous with the Single Exception of Psilotum reported ly Zimmermann. Thoreour apart from a few quite insufficient observations be are still Entirely in the dark regarding their true nature, their dignificance their origin + their fate. Districts by thent observation Bornited potentionion Compositae I was interested to find brois while resembled the monocotyledonous Eleioplasts occarring in the tiones of the floral region of Gaillardia This would Estend the distribution of Elacoplasts to a member of the Dicotyledons. My first Indeavour was to make (a) Gaillardia Lorenzeana is a German Variety of G. picta while stack appears the only a garden for Variety of G. palchella. I have not yet had an apportunity of Examining any other wants, form or species of Gaillandie Except the one trentined above

I was dealing with Sure that the Plainplests. In the Theirs upon the percenth of young flowers, where I forst observed these bodies they occur as more or less Spherical, highly refractive, grafind granular Structures would somewhat larger than the nucleus or in most cases lying bengly in a cell although two or Even were Such bodies were Occasionally met with. Heated Sently upon the Slede (whelst lying is a physiological Salt Solution araps of oil we Exuded from their Surface; in some and (as this occurs in Flamming's stronger solution) they are blackened; alkannin solution is 60%. al whal colours to bodies deeply red; dodine Solution (in RJ) colones them brown; absolute alcohol dissolves out the oil from their interior of leaves then Vacuslated. in nitrice and (warmed) + Subsequent addition of ammonia the fine the × antho protece realten;

Their reactions were found to be as follows: -

(1) Healed gently upon the Slice (whilst lying is a physiological Salt Solution) drops opoil are Exended from their Surface (Fig 13)

(2) Odmic acid (as this occars in Flemming's Stronger Solution) turns then black or brown.

(3) Potassium bichromate after 24 hours action haves them quite colombers but causes the saturain Foil globales [as in (1)].

(4) alkannin Solution in 60% alcohol colours the Digitized by Hunt Institute for Botanical Documentation

(5) Forme (in KJ.) colours them brown + causes the Estración of oil . globales (4/2/2)

(6) absolute alcohol dissolus out the oil from their interior of leanes them Vacuolated.

(7) L strong HNO3 (werned) followed by NH3 they sense the xanthoporteic reaction (vin yellow colonation).

(8) Glacial aceter acid after 24 hours action causes great rabusin of oil drops but no solution.

(9) 10% KOH. after 24 hours action dissolves weither strome nor oil draps.

These reactions, combined with their general appearance will show that the bodies occurring in the wills of Gaillandia are in all respects similar to the slaiplasts described & previous authors.

on very young heirs from capitula which were succeed inthin Still quite small + immature + sulviel thought Digitize to Huntersienback of the care as percentation get to be sean. The all contained a muchers 4 Hammetel cytoplasm which partly formed a periphral layer + parts saturded as in a strends + bars to the unite (7igs 1+2) the Embedded in the cyloplasm were a number of Very small highly refractive grains which had all sung appearances of ordinary leucoplasts. The fact that these repractine grains are really leacoplasts is some of two facts. Firstly the resemblence between the unquestionable Starch - forming laucaplasts occurring the hairs capa the very young leaves of the tighty refractive grains, in the persenter-bairs is complete aethorgh stand is not found, under the usual conditions to latter of growth. Secondly if the Enveloping bracks he removed from the hours upon to percent - hairs sapared & a Strong insolation starch can be seen and by Hant Institute for Botanical Documentation of these refractine grandes grans. For these reasons I believe the highly repractine greens occurring in the cells of the personet - hours to be leacoplests, or promets some of while however, may have lost the dample pomer of Starch formation

In Somewhat older hairs these plastids some of which shows signs of underloning degeneration," tend to aggregate together at one or more Spots within the all. Smale Not infrequently this aggregation of the pleaseds is in the neighbourhood of the nucleus but in many enstances it is found to occur at other regions of the cell . (7igs 3 + 4) at forat the aggregation of the repartine grains is a voy losse one but it gradually zed by Hynt Institute for 45 Danica to Jocumen 7 a grows closer + closer until todas compact, highly refractive bodies are formed which the have abready recognised as clauplasts The elacoplasts in the persenth - hairs of Gaillardia are therefore, formed & the affrontion of plastids of their products of defended a possibly associated with Some Cytapleson as well at one or hore Spots in tou cell Within the Elacoplast I have the plantides appear) Soon to undergo further degeneration with the

production of an oily material. That Limmermann should find a close Similarity between the oil of the Placoplasto Studied by him + the oil obtained from plasteds is no longer Surprising. all the planteds the of the all have not clumped together within the rhaioplast. a cortain proportion till him to the pompting through the cell. (7,8 7). itized by Hunt Institute for Botanical Documentation married together in this menner whitst oltus while For Some time there is little elteration within the call. In considerably older hairs, Thomas, bu find For some time there is little and alteration with the cell. The conspicuous Slacoplast may hie in almost any part of the cell but often it takes up a position near the

uncleas. In some instances it soutinely somelapes the nucleurs as I have represented In much older hairs we find the claisplast endergoing a change. It's orthere becomes less reguler & in Some cases it becomes drawn out + Slongaled in form (459) faintly yellow it a le coming detached from the main Digiti Lolly It the draps in galaces light Delangelistion on gradually as callered through the cell cavity (Fig 10) Nore they deepen their yellow tent + in association with the red pequent developed in the cell-Sap they so produce the yellow orange or red colomatin 7 the mature perianet - hairs according as the one or the other prementing natural predominates (Fig 11).

The constituent plastices of tree Plaisplasts, therefore underes & quite a Similar Series of Changes as the Chlorophyll Greins in autumn banes, first described in detail by Sachs in 1863 (10) or in repening prints also studied by Sachs (1865) that well as attended by Sachs (1865) the mollandon the hairs are fully matured the litu Plaisplast has entirely resolved itself into the Scattered yellow pignent of the cell.

Digitized by Hunt Institute for Botanical Documentation

The perianth-hairs are not the only place in which Elaioplasts occur in Gaillardia. I the Stignation tains they are to be found in the Stignation tains in the more internal cells of the Stigna + of the Style in the Vegelaline cells of the anther 4 in the cells of the young pappas (calyx). I sought for them in Vain in the Post - heirs of the tirsues of the root in the leaf or

to the hairs which cover it, in the stam of its clothing of hairs.

after I had completed the study of the elaiptents in the periante have of a drawn the conclusions which I have supressed above I received a beautiful confirmation of the correctness of many views for the study of the slaiplasts in the other floral regions of Saillardia.

Digitized by Hunt Institute for Botanical Doc 190 mentation of the cells of the connectine of the Slamen bodies occur which redemble the Plaisplants of the periant hairs in Enough respect sample that the are coloned more or less deeply steen. They are mostly spherical although sometimes Plongated in shape. (Fig 14)

Moreover in neighboring cells of the connection we find Energy transition between the deeply seen bodies of this description of this description of others which are quite colons of differ in

no respect for the claiplests already of the peranet - hairs. On the addition of Indine Solution the occurrence of starch within the green bodies is readily demonstrated ; the less to gran pignes (Fig 12) after remaining in the Lodine Solution for some homes these deeploy black stained bodies for the most conspicuous feature in an otherwise yellow cells. The appearance + reactions of the veen Digitized by Hunt Institute for Botanical Documentations occur belineen them I the ordinary claiplests leane no doubt that they are slaiplests while have descloped for stand chlorophyll + Telained the power of starch formation. The cells of the Style + Stegma also possess green, starch- producing slavaplants. Enother very interesting position case of Eles of the flattened & that flattened basal plates, of the young pappus. E

In many of these cells scattered chloropleats occur arranged as in ordinary assimilating terosure 1 These chloropleats are large of contain draps draplets of this substance. Probably these oil-drops are week to first Stage of degeneration although the angestine power of sterch - for sten has not yet been lost. I was at first inclined to believe that the only drops witting the chlorophyll corpuseles represented the normal grana of these hodes developed to a rather unusual satent. The fact, town, Unt the charpfull chloroplasts of the setur organs of Gaillardia (E.g of the lay) do not Show any distinct grana of this kind complete with the for further fact that the plantes of the papper soon suguelon show undoubted signs of defeneration has lead me to conclude that the oil-drops are associated with the degradation of the chloroplasts.

I other cells lying quite hear to thre with

Scattered Chloroplasts are oftens in which three bories tend to have more or less loosely together. I other cells again the aggregation of the Chloroplasts is closer although the outlines of Each deparate plasted is still maintained to a further step in this aggregation of the Chlorophyle bodies is so seen in other neighbouring cells in which they become so closely clumped together that the outlines of the individual chloroplast can no longer be distinguished to we obtain a Digitity private Hughern till characteristical plaster in other outlines.

drops of the plastids produce the finely granular appearance characteristic of these

Structures

all these stages way he observed in adjoining cells of one + the same pappus-plate. They are best studied at about the time when the young polar grains are still without a membrane of their own + are smoologed in the special-wall (special mother-cell stage)

In older pappus-plates the green colour of the elaioplasts genies place to yellow to alter degeneration processes become soident.

Now that the development of the Placoplest has been followed in at least one Species he are is a better position to compare this body with the oil-bodies of Hepaticae. Wakker evidently believed in the identity of the two structures whilst other authors - Such as you will be structure for Botanical Docopposite tito opinion. On coparing what he's been weet written above method regarding to elaroplests of Gaillardia with Tarjeannes careful account of the development of the al - boties of Several Jungermanniales it will be seen that the two Structures have a very different origin. In the latter the oil-brown arise as Vacuoles in lin cytopleam whelat we have seen that the Slacoplesto of

Gaillardia are formed by the aggregation of plastids of their degeneration products. Whilat threspre, whe cannot as get draw general conclusions as until often species sceneral and fully say that the developmental history of the classificates of Gaillardia is sometially different from that of the oil bodies of the Hepaticae.

Estornal conditions Seem to Exert Very little influence Digity exaby Heigh Institute for Botanical Rocumentation total darkness for segural (3-9) to Single days without altering the Stanton development or Structure of the Slaroplests of the personel hairs in the least. The only deviation which I have row found is the behavior of the pleateds of the perialt. havis occurred in a very young capitalian what from which the protecting town tracts had been distrected away so that the flower-buds were

exposed to the full effect of the light. Here the affregation of the plantides into relainflants had been relarded in a number of cells.

The clumping together of the plastids of a cell with a more or less close mass is by no means an unusual occurrence. Hraws (12) many years ago described the Effect of cold upon the chlorophyll-grains of winter leaves. Here there chlorophyll-grains of winter leaves. Here there interior of the cells & were there aggregated in clumps. Charles & arwin (13) in 1882 observed a very close massing of the chlorophasts in the cells of certain insections plants under the influence of ammonium carbonate (a solution of 4-7, ammonium carbonate the 1000 mater)

The work of Stable 1, as well of others, her shown that an irregular affregations afterchloroplests is produced ander the influence of interse illumination. In Pfiffer, mentions that Similar results are induced & injuries + Various me chemical agencies. ar the close wassing of the plasteds into compact Slauplasts is most probably connected with their defeneration a may want likely be compared to the aggregation of these bodies produced of the injurious agencies Enumerated above. That Digitated report of state tang of apart calactiment part to play in the function to perform which is of direct Significence to the life of the cell is most unlikely. They are Structures which The plantides the mo longer useful required of importance of as assimilating or anytoplastic organs + The a Secondary use for the defeneration products of to pleateds - meraed auto slanoplasts - my certainly does occur in the case of the periantehairs of Laillardia for here the spin rise to the spellow pignant which forms an part of the attraction apparetus of the mature flower. It often Situations, atte clairplants appeared in without hering over this chance of histogrial Significance.

It will be interesting to I amine the homoerty have slain prove closely in the light of the above what has been learned of these bodies Digitifically and Institute for Both they among the stain Same hature of history. I hope to obtain material for this purpose during the next Season.

de emolusion I must supress my indebtedness to a to Government Grant E. for a Leis I'm to N. A. oil immersion land which has greatly facilitated my observations.

for assistance is carrying out this research.

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(1) Claiplants which butterto had only been met with is here cotyled one (& Psilotum) have now been found to occur in a Dicotyleton - Jaillardia -. (2) The Elacoplests occurring in the perianth-trains of Laillardra are found to agree in their their appearance of in their behaviour towards reagents with the Slavoplasto described by Wakker & Lummermann in Mons coty levous. (4) They have been found in the persenth - hairs Digitized by Hunt Institute for Botanical Documentation the connection of the Stamens, the Style of the Stigma of Faillardia. They are absent from the lesses of the Stern, the root of the leaf of this plant. (5) They are formed by the aggregation of the touseplests plasteds of tweel + their defeneration products at me or more Spots in the cell. (6) In the perianth - hairs of Laclandia they give

rise to the oily, yellow pigment which in association with the red cell-sap gives the mature hairs of the flower their characteristic of colors.

(7). The elaispleate occurring in the Stevens of items

Style & Stigma of Gaillandra agree in all

respect with those of the porcenet hairs

sacept that the are coloured green of form

Sterch within their Substance. In them

reighbouring calls of these tissues all

itized that Institute has otanged. Documentation

Coloned bright green & those which are about colonlers like those of the periante-hairs.

(8) In the terrores of the plate of the young papper sury transition can be found in neighbouring cells between those which contain scattered chloroplests satirely free from me another of those in which the chloroplests have clumped together to form a sure green mass identical with the green slaipplests of the stemm or the Stepna.

The elaiplests of Gaillardia (+ probably other homocotyledonino thanperts also differ Essentially in their development from the bil-bootes of the hiervorts. (10) Gaternal conditions were found to saint very lettle influence upon the appearance of the Stainplant although interest Strong direct illumenation seemed in one case to have retarded the affregation of the Digiti The close massengle of the plastiles into compact Elaioplests is probably connected with their defeneration or may be compared to the aggregation of the pleatids under the influence of various (mother unions) agencies described services patrons.

It is most unlikely that the clariplants to a any function of direct emportance to the life of the plant although they may be in Some ceaes (peranth-haus of Taillanta) & serve a Secondary, biolical purpose.

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Benegungsersch. im Pflanzenreiche"

Explanation of Figures in Plate -

all the figures refer to tissues of Gaillardia Lorenziana. Del Preparations racumed & drawn in . 6 % Nacl Solution unless otherwise Stated. Fig 1. Very young cell of percenth-hair before Slaiplasts have developed. Lew caplasts distributed in the cytoplasm × 10 45 Fig 2. Upex of another periante-hair showing Digitized by Hund Institute for Botanical Documentation Fig 3. Forng cell of penanth-hair showing an Early stage in the aggregation of plantide Fig 4. Personth-hair showing a sawlet X 650 Stage in aggregation of plantide × 650 Fig 5. Periante- hair with later stage of Elacapleat development. X 650 Figs 6 , 7 8. Elaioplast completel developed in perianth - Lairs. X 650 718 9 Older to Cell from older pereanth-hair. * Ulaioplast Flongated & Shrwing forst

indication of disintegrating x 650 78 10 Later Stage; Substance of claioplest becoming distributed through the cell 7811 Mature peranth-hair. Fellow pignent-- material derived from Elacoplast completely distributed through the all x 650 7/8/12 Freen Elacoplast from anther after 2 days a delete tooine Solution Hurrishape the Rollmond Boundentation Surface. Starch (Show in the figure as black grains) contained in the yellow Slaved matrix. X 600 Marsplast from penanth hair in 7/8 /3 . 6% Na Cl after gently warming on Slide our Spirit lamp x 650. Fix 14 Green classflast in cell of anther Figs \$6 15 + 16. Two neighbouring cells from plate of pappus. 2 pig 15 the chloroplasts are Scattered whilst i pig 16 they are hard wared into a loose clemp. Note oil drops

within the chloroplests (represented as black dots) X about 600.