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Desiccation and decay of the cells of the red cabbage.

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In his previous papers*) the author asserted that the decay of desicated cells in plants is caused by mechanical processes only. In consequence of the loss of water the autor pointed out, that the volume of the central vacuole is diminished and that at the same time the form of the cell changed. But the wall of the cell again takes its previous form, after having been deformed, very quickly, if it is put into water and absorbs it. The cell wall then becomes greater in volume and throws off the protoplasm. There is no doubt that the protoplasm endures purely mechanical injuries by drying and becoming wet and that in this way its structure is destroyed. From this point of view we see the importance of thoroughly studying the processes, which take place during desiccation and moistening of the cell tissues in plants. But in this short commentary we will describe only the main experiments about these facts, and describe only such experiments which refer to cells of leaves of red cabbage, where the cells contain a red anthocyan in the cell sap. The coloured sap of the cells, in these experiments, is of adventage in respect to the fact that it facilitates the precise analysis and gives possibilities for a control of moments, in which the cell is going to die. The author performed the microscopical investigation on living cells in special small receptacles**), in which the relative moisture of the atmosphere could be changed artificially. It has been found that the epidermal cells in red cabbage contain very deeply coloured drops of anthocyan and that the number of these drops increases very rapidly during the desiccation processes. Afterwards the author found that the drops smelted together and finally that they changed themselves into a coloured group of matter or divided themselves into some largish parts of such a matter (see fig. 1).

The form of desicated cells can be very different (see fig. 2). If the drying processes proceed only slowly, we find that the protoplasm and the cell sap accumulate on lateral walls of the cells regularly (A) or irregularly in certain places (B). The anthocyan crystalizes only in a few cases (C). If on the other hand the desiccation processes proceed more quickly, the protoplasm and the vacuole divide themselves into several parts (D), which become then of spherical and very characteristic form.

If the dry cell is made moist again or put into an atmosphere saturated with water-vapour, then we can observe just the reverse processes. Here we have two possibilities: firstly the dried cell can contain a small amount of liquid

*) Jahrb. wiss. Bot. 1927, *66*, p. 947; Protoplasma 1930, *10*, p. 379 and 1931, *13*, p. 322.
**) Detailed description of this method in Jahrb. wiss. Bot. 1932, 77, p. 220.

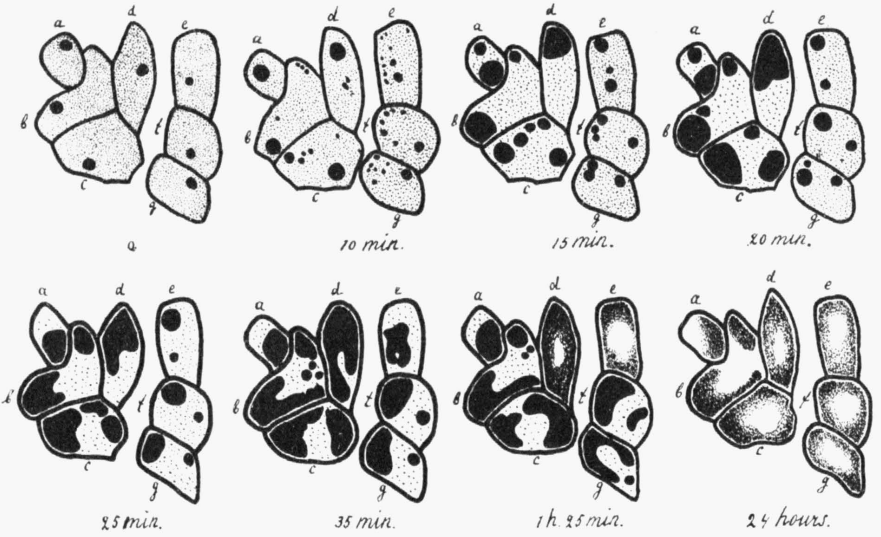

Fig. 1. The appearance and the melting of the anthocyan-drops during desiccation.

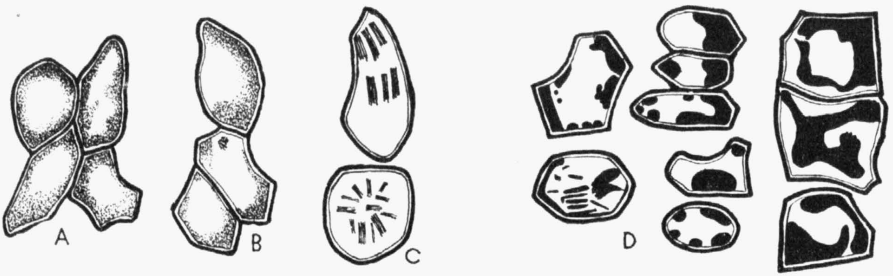

Fig. 2. The different types of desicated cells.

water, or secondly the cell can have no liquid water at all. In the first case we find that the great and deeply coloured vacuoles diminish gradually and give their contents to all parts of the cell, which then becomes coloured (see fig. 3, A, B, C, D, E). In the second case the coloured vacuoles appear again. These facts are clearly seen from the illustrations and may be followed very easily in some cases which are described particularly in the following. Thus we see (fig. 4) in the first case a fresh cell, then its drying up and then again its becoming moist. We may follow first how the vigorous cell, after having been satisfactorily saturated by water contains a small drop of deeply coloured anthocyan (fig. 4, A). In the next moment we see how at once a great number of small drops appears during the desiccation process (B), and how finally these successively smel together in a somewhat greater drop (C, D).

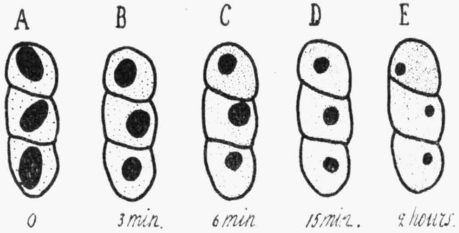

Fig. 3. The dissolving of the anthocyan-drops in water.

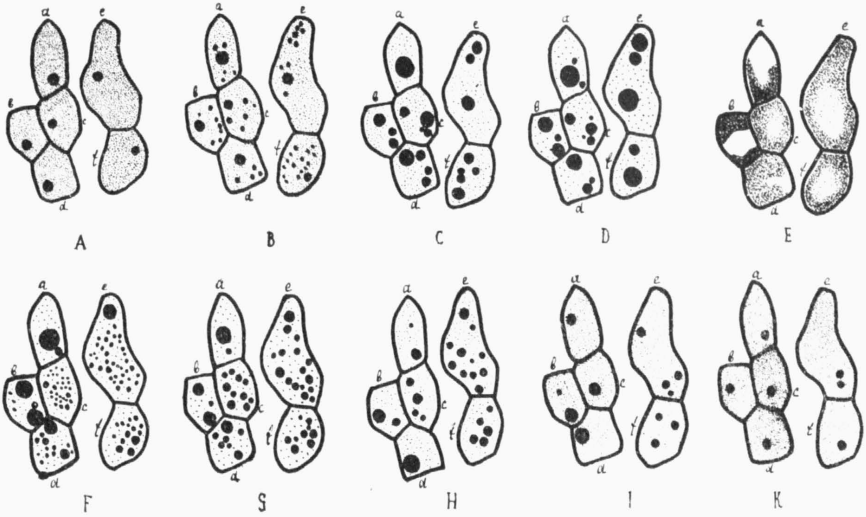

Fig. 4. The appearance and the disappearance of the anthocyan-drops during desiccation (A—E) and moistening (F—K) of cells.

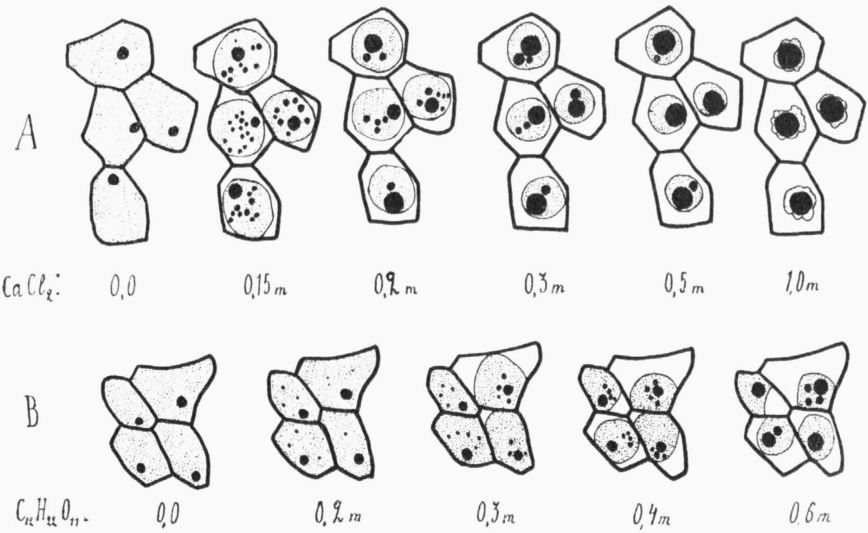

Fig. 5. The appearance of anthocyan-drops in concentrated solutions of calcium chloride (A) and of cane-sugar (B).

The number of these drops diminishes gradually up to the time, when the desiccation process ends and the drops change themselves into one formless mass, which presses then the protoplasm against the walls of the cell (E). On the other hand, if we put the tissue into an atmosphere which is saturated by water-vapour, we can see how a greater number od small drops of anthocyan appears in the protoplasm (F), and afterwards how they flow together into larger ones, which in the next moment dissolve themselves again (G, H, I). In such a way

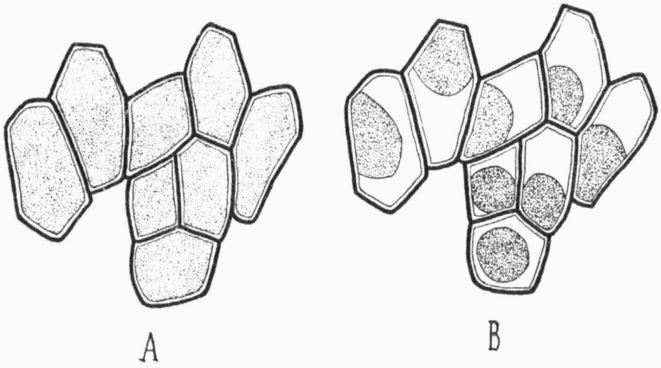

Fig. 6. A — the desicated cells. B — pseudoplasmolysis in water.

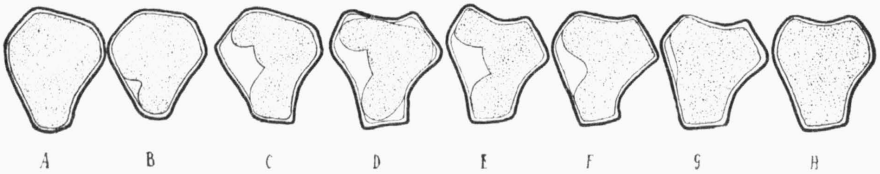

Fig. 7. The various stadiums of the pseudoplasmolysis (B—D) and of the pseudodeplasmolysis (E—H) in water of the same cell. A — dry cell.

we finally get again only one deeply coloured drop in each cell (K). We see that the cell has returned into its original condition.

There is now no doubt that this originating of and dissappearence of drops of anthocyan depends only on the quantity of water contained in the cell. On the other hand the same resulting process could be obtained, if the tissue is put into concentrated solutions. Such a case is demonstrated in fig. 5. Here we see a tissue, which has been gradually transferred from pure water first into less and afterwards into more and more concentrated solutions of calcium chloride (A) or of sugar (B).

The drying of the cells results in an increase of the protoplasm viscosity. The protoplasm becomes less fluid and less motile. Through wetting with water the cell wall swells very rapidly, or nearly at once, so that the wall quickly gets its original form. But the protoplasm has no possibility of following this change and of swelling with the same velocity and pulls away therefore mechanically from the wall. The cell then looks as though it has been treated by plasmolysis (see fig. 6 and 7). But such condition does not remain for a long time, because the central vacuole again absorbs the water, consequently enlarges its volume and presses the protoplasm more and more against the wall. This moment is really of great danger to the life of living protoplasm, because now the translocation and destruction of a normal structure of the living protoplasm takes place. In fig. 6 we see in connection with this firstly cells in dry condition (A), but next after they have been transferred into water (B). In all these cells we find such an appearence as if the cells had been treated by pseudoplasmolysis. In fig. 7 finally we find the various grades of plasmolytic and deplasmolytic processes in one and the same cell. We find that the majority of cells treated by plasmolysis cannot live any more and die.