ANTIPODALS IN ZINNIA

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The antipodal region in the female gametophyte of the Compositae has been extensively studied in recent years, and great variation has been found to occur with regard to its developmental history and final structure. As Schnarf has fully summarized our knowledge a few years ago (1929), the existing condition need be only briefly sketched here.

As a rule three uninucleated antipodal cells are initially formed in most of the Composites. Subsequent nuclear divisions may take place, generally accompanied by irregular wall formation. The number of resultant antipodal cells may be so high as to give rise to a so-called antipodal tissue. Equally, the number of nuclei in each individual antipodal cell may range from one to many.

In other cases only two antipodal cells are formed, the chalazal one inclosing one nucleus and the upper one two nuclei. The nuclear divisions that may occur in both cells, are seldom accompanied by wall formations. Thus only two antipodal cells, containing generally a great number of nuclei, will be present. Examples of this antipodal type are presented by several genera in the subfamily Heliantheae. A two-celled antipodal region has been described for example from *Bidens* (Dahlgren 1920), *Cosmos* and *Cosmidium* (Täckholm 1916), *Helianthus, Sanvitalia, Verbesina* and *Zinnia* (Hegelmaier 1889) and *Senecio* (Afzelius 1924).

It has been found that nuclear fusion often takes place between groups or between all of the nuclei present in such antipodal cells. Such fusions are said to be a more or less regular feature in the giant antipodal cells of *Cosmidium* (Täckholm 1916) and some *Senecios* (Afzelius 1924).

A chance inspection of some slides of the common garden *Zinnia* (*Z. grandiflora*) showed nuclear conditions in the antipodals of the embryosac which are of interest, adding as they do, a new variation to the many already observed in the *Heliantheae*. Incidentally, the antipodal development in *Zinnia grandiflora* gives a probable explanation of Hegelmaier's (1889) views regarding the origin of the female gametophyte in the Compositae.

Out of a row of four megaspores, the chalazal one gives rise to the embryosac. By the ordinary two successive nuclear divisions, two pairs of nuclei are formed in the developing young embryosac. All four nuclei then divide simultaneously. Of the resulting eight free nuclei, three constitute themselves into a perfectly normal egg apparatus; two of them give rise to the polar nuclei (fig. 1).

In the antipodal region the remaining three nuclei take up a linear arrangement. Between the uppermost of these antipodal nuclei and the lower polar nucleus a partition wall is laid down generally at right angles to the longitudinal direction of the embryosac. At the same time a second wall separates the two chalazal antipodal nuclei from each other, forming two antipodal cells with one nucleus each (fig. 1). No exceptions to this nuclear constitution were noted.

The subsequent behavior of the antipodal nuclei may proceed in two directions. In most cases seen, the two nuclei of the upper antipodal cells move to the centre of the cell where they fuse (figs. 5-8). Relatively rare is the occurrence of four nuclei in this cell; when four nuclei have arisen, fusion between at least two of the nuclei may take place (figs. 9, 10). Quite rarely the four nuclei remain separate (fig. 11) in old embryosacs (the age is indicated by the development of a massive endosperm structure).

The nucleus of the chalazal antipodal cell remains undivided; because of its small size this cell plays a correspondingly minor part in the antipodal system (figs. 2, 3, 4).

It is of interest not only that a fusion of antipodal nuclei occurs but that such fusion occurs with remarkable regularity. The nuclei, in preparation for the fusion, move to the center of the antipodal cell, as already indicated. Contrary to what could be expected, the fusion always seems to take place when the nuclei have moved to such a position in the cell that they lie side by side. Figures 5 to 9 illustrate their position in relation to each other and the main axis of the cell as well as some successive stages in the fusion processes. During the beginning stages of fusion one or both of the nuclei show changes in shape, being flattened or even of a somewhat amoeboid outline. The originally rather distinct nuclear membrane gradually looses its distinctiveness at the surface of contact between the nuclei (figs. 6 and 7). At the same time, there generally seems to occur a gradual augmentation in the number of nucleoli as well as in the intensity with which the chromatine takes the staining material. In figure 8 there remains barely a shallow double indentation, indicating that we have to do with a fusion product of two nuclei; the chromatin elements of both are already completely united. The events described have generally taken place before the nuclei of the fertilized egg cell and primary endosperm show signs of division activity (fig. 4). No cases were observed from which it could be inferred that an antipodal fusion nucleus would divide later during the development of the endosperm.

Should the original two nuclei of the upper antipodal cell give rise to four nuclei, one pair of them may fuse, as indicated above, or all four may unite in one giant nucleus, if they do fuse at all. Figure 10 shows a case where the big lower nucleus is the result of a fusion; the small size of the upper two nuclei is due to the fact that their main bulk is to be found in another section. Figure 9 pictures the rare instance of a fusion of all four nuclei. Here the fusion product still shows in its outline the traces of the four participant nuclei.

The more or less constant fusion of the two nuclei in the upper antipodal and its occurrence at a rather early stage in the life history of the embryosac of Zinnia, in all probability explains Hegelmaier's error in interpreting the development of some Helianthoid embryosacs. According to Hegelmaier, the lower megaspore out of a row of four developes by consecutive nuclear division into a four nucleated embryosac. At each end of the embryosac the pair of nuclei were found. Thereupon the micropylar pair proceeds to form the egg apparatus plus the upper polar nucleus in the usual way. So far his account coincides with the normal sequence of development. With regard to the nuclei of the basal pair, however, he states that they do not undergo any further division but, after having separated, each of them forms an antipodal cell. The lower polar nucleus would thus be absent. He found this type of development characteristically enough in aberrant *Zinnia tenuiflora* and other members of the *Heliantheae* (see above) which, as we now know, constantly have two antipodal cells.

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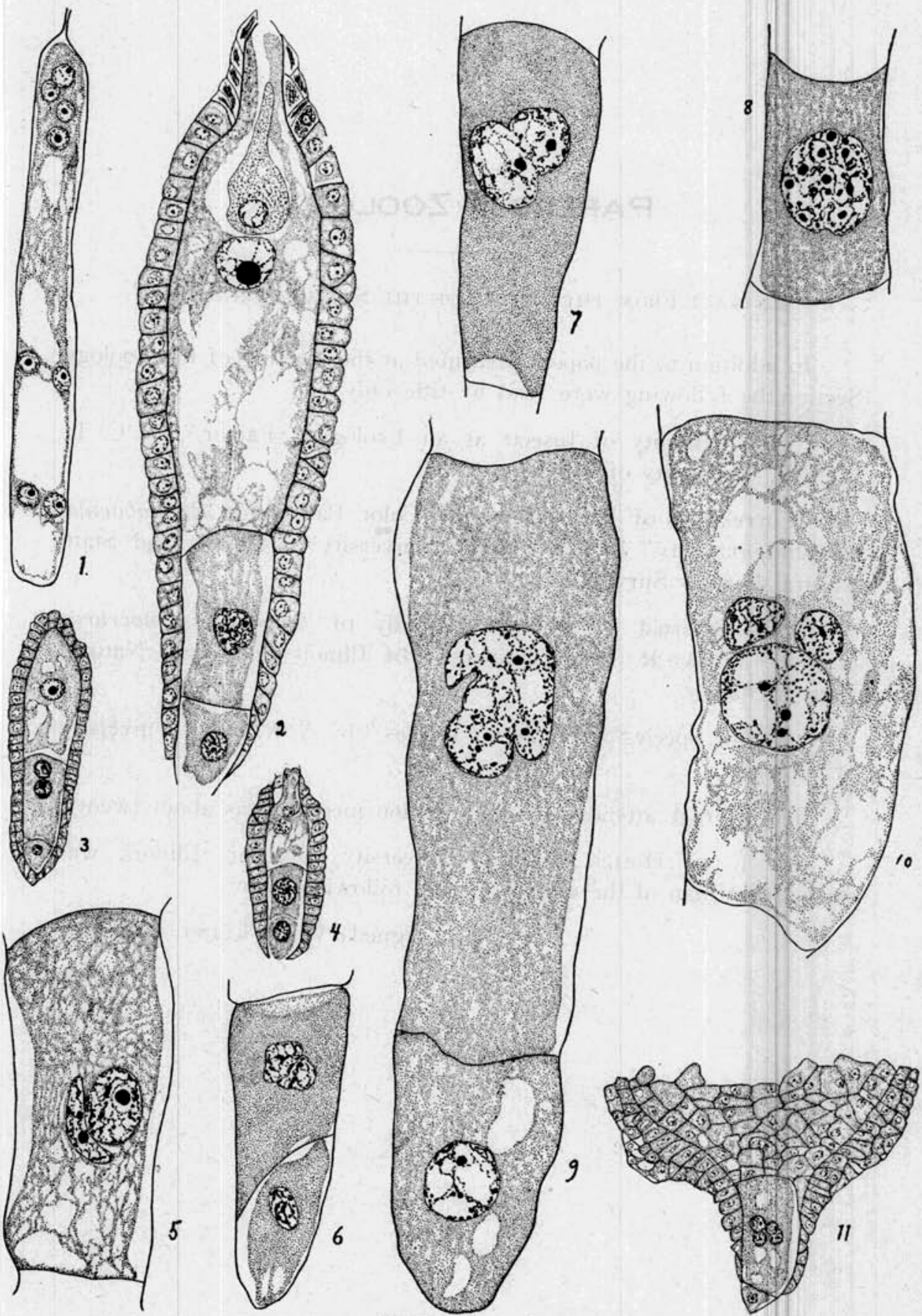
EXPLANATION OF FIGURES

ZINNIA GRANDIFLORA

FIG. 1. Eight free nuclei in the embryosac.
FIG. 2. Embryosac ready for fertilization.
FIGS. 3 and 4. Embryosacs with two antipodal cells, the upper one of which contains two resp. one nucleus.
FIG. 5. Early stages in the fusion of two antipodal nuclei from the embryosac shown in figure 2.
FIGS. 6 and 7. Consecutive stages in the fusion of two antipodal nuclei.
FIG. 8. Fusion nearly completed.
FIG. 9. Fusion product of four nuclei from the upper antipodal cell.
FIG. 10. Antipodal cell with three nuclei; the largest one formed by the fusion of two nuclei.
FIG. 11. Antipodal cell from old embryosac with four free nuclei.



FIGS. 1-11.