

THE SUPERNUMERARY POLLEN-GRAINS OF FUCHSIA.—In the great majority of Gymnosperms and Angiosperms four pollen-grains are produced from each pollen mother-cell.

Exceptions to this rule are, however, not wanting, and Coulter and Chamberlain¹ record (largely from Wille's observations) no less than twenty-three species in which a greater or less number of pollen-grains than four have been seen to arise from one mother-cell. To this list other names might be added, but I will only mention here that of *Aesculus Hippocastanum*, in which I have several times observed six microspores lying within one mother-cell wall. The manner in which this deviation from the normal number of microspores is produced has only been investigated in a very few instances. Apart from certain hybrids, such as *Syringa rothomagensis* (Juel²) and *Bryonia* (Tischler³), which form a rather special case, there are, so far as I am aware, only two forms in which the cytological processes underlying the production of an abnormal number of pollen-grains have been worked out. Thus in the Cypereaceae (*Heleocharis*, *Carex acuta*) the work of Elfving⁴, Wille⁵, Strasburger⁷, and Juel⁶ has shown that, whilst the mother-cell nucleus divides twice in the usual way, three of the nuclei thus formed degenerate, and only one microspore (surrounded by the thickened mother-cell wall) is finally developed from the mother-cell. Again, in *Hemerocallis fulva* Strasburger⁹ and Juel¹⁰ have shown that, during the anaphase of the first and second divisions of the mother-cell nucleus, the chromosomes are often irregularly distributed upon the spindle so that some of them, either singly or in groups, do not reach the poles, but become separated from their fellows, and each such group may give rise to a distinct nucleus. Each nucleus thus formed usually becomes the centre of a separate cell, so that a larger number of daughter-cells than four is frequently produced from a single mother-cell. Fullmer¹¹ (like Tangl¹² at an earlier date) is inclined to attribute at least some of the supernumerary microspores of *Hemerocallis* to the subsequent division of one or more of the tetrad nuclei, but Juel¹³ entirely repudiates this suggestion. I have recently examined the pollen development of the ordinary greenhouse *Fuchsia*¹⁴, and I can fully confirm previous writers with regard to the occurrence of supernumerary pollen-grains in this plant.

As long ago as 1850 Wimmel¹⁵ called attention to the irregularities in the number and size of the pollen-grains produced from the mother-cell of *Fuchsia*, and in 1886

¹ Morphology of the Angiosperms, 1903, p. 125.

² Pringsheim's Jahrb. f. wiss. Bot., Bd. xxxv, 1900, p. 638.

³ Berichte d. deutsch. Bot. Gesellsch., Bd. xxiv, 1906, p. 83.

⁴ Jenaische Zeitschr. f. Naturwiss., Bd. xiii, 1879.

⁵ Christiania Videnskabs-Selskabs Forhandling, 1882, No. 16.

⁶ 'Ueber die Entwicklungsgeschichte der Pollenkörner der Angiospermen,' &c., 1886, Christiania, p. 43.

⁷ 'Neue Untersuchungen über den Befruchtungsvorgang bei den Phanerogamen,' &c. Jena, 1884, p. 11.

⁸ Juel, l. c., p. 649.

⁹ Archiv. f. Mikrosk. Anat., Bd. xxi, 1882, p. 497.

¹⁰ Pringsh. Jahrb. f. wiss. Bot., Bd. xxx, 1897, pp. 205-6.

¹¹ Bot. Gazette, vol. xxviii, 1899, p. 81.

¹² Denkschr. d. Kais. Akad. d. Wiss., Bd. xlv. Wien, 1882, p. 73.

¹³ Pringsh. Jahrb. f. wiss. Bot., Bd. xxxv, 1900, p. 646.

¹⁴ The pollen development of several different species of *Fuchsia* will be described in the full paper.

¹⁵ Bot. Zeit., Bd. viii, 1850.

Wille¹ counted five, six, seven, and even fourteen microspores arising from a single mother-cell.

Moreover, Wille offers an explanation of the manner in which these additional pollen-grains are formed. Thus he writes, 'In dem Falle, wo bei *Fuchsia*, sp., 7 Zellen entstanden waren, konnte ich nicht darüber im Zweifel sein, dass dies daher kam, dass drei der Zellkerne der Tetrade noch sich einmal geteilt hatten, ehe die Cellulosequerwände ausgebildet waren, während der Vierte ungeteilt blieb.' Where five or six microspores were produced he believed the explanation to be similar. In the case of the higher numbers (14) he was unable to follow the cell-divisions, and is uncertain whether the additional pollen-grains are due to secondary divisions of one pollen mother-cell alone, or whether they are to be derived from two or more primitive mother-cells (Urmutterzellen) which have not become separated from one another in the usual manner.

I have frequently counted six, eight, and ten microspores lying within one mother-cell wall of this plant.

A study of the nuclear divisions of the mother-cell has shown that the high number of pollen-grains produced is due to the occurrence of irregularities in the distribution of the chromosomes during the anaphase of division, quite comparable with those described by Juel in *Hemerocallis fulva*, and no facts have been found to support Wille's explanation.

The prophase of the first division appears to take place in quite the normal manner, but during the anaphase it is seen that the numerous, small chromosomes frequently move very unevenly towards the spindle poles, and some, either singly or in groups, lag behind the rest and often become entirely cut off from the two main chromosome groups. Usually these separated chromosomes give rise to distinct nuclei, which vary in size according to the number of chromosomes they receive. A few cases were, however, observed in which the scattered arrangement of the chromosomes appears to have been such, that separate nuclear walls were not formed round each chromosome or group of chromosomes, but one lobed nuclear wall was produced which enclosed all the scattered chromosomes within its embrace². It also occasionally happens that the separated chromosomes fail to become organized into distinct nuclei with nuclear walls, and in that case they appear to degenerate in the cytoplasm without taking any further share in pollen development. These cases are, however, infrequent, and in the majority of instances each detached chromosome or chromosome-group gives rise to a separate nucleus.

During the second meiotic division the small, as well as the large, nuclei undergo karyokinesis and produce a distinct spindle.

Often only two chromosomes can be seen to occupy the equator of a miniature spindle, and in some cases I believe only a single chromosome was present.

The second division of the mother-cell nucleus is much more regular than the first, and up to the present I have not found that any of the supernumerary nuclei originate at this stage. The nuclear divisions of the mother-cell which have been

¹ Ueber d. Entwicklungsgesch. d. Pollenkörner, &c., 1886, pp. 60-1.

² In some cases the lobed nuclei almost suggest the existence of amitotic divisions. After a careful comparison of all the preparations showing the phenomenon, I believe, however, that the interpretation given above is the correct one.

described above are followed by cell divisions. Thus the supernumerary pollen-grains are produced by the organization of distinct cells round all the nuclei, whether these have been formed in the regular course of mitosis, or by the isolation of irregularly distributed chromosomes.

I can find no evidence of the existence of secondary divisions of the cells such as Wille described, nor do my observations give any support to this author's suggestion that a fusion (or non-separation) of primitive mother-cells (Urmutterzellen) might occur in those cases in which the additional microspores were very numerous.

A definite relation appears to exist between the number of chromosomes entering into a nucleus, the size of the nucleus, and the size of the cell produced.

It may be further added that the small cells, with only a few chromosomes entering into the composition of their nuclei, develop pollen-walls, which differ neither in structure nor in chemical composition (viz. they give the same staining reactions) from those surrounding the pollen-grains which have received the normal number of chromosomes.

It will be seen that these facts have an interesting bearing upon the theory of the localization of specific characters in particular chromosomes, but the discussion of this matter must be left for my full paper upon the pollen development of *Fuchsia* and some other plants.

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CONTRIBUTIONS TO THE CYTOLOGY OF *HUMARIA RUTILANS* FR.

(PRELIMINARY NOTE.)—*Humaria rutilans* is a small orange Discomycete occurring in abundance on sandy soil. It possesses exceptionally large nuclei, the nucleus of the uninucleate ascus measuring about $14\ \mu \times 9\ \mu$.

The ascocarp originates as a tangle of septate hyphae, each cell containing one or a few nuclei. Sexual organs are not differentiated. Very early a sheath of rather thick-walled cells can be distinguished, and within this ramify numerous hyphae, growing upwards till, while the ascocarp is still quite minute, paraphyses and subsequently asci appear. At and rather before this stage two sorts of hyphae can be distinguished in the hypothecium by the size of their nuclei, though they do not otherwise differ: The larger nuclei are about twice the size of the smaller, and are formed by the *fusion of these in pairs*. This would appear to constitute a process of reduced fertilization, or apogamy, quite comparable to that observed in the prothallus of *Nephrodium*, and representing a stage in the reduction of sexuality more advanced than that found in *Humaria granulata*, where an ascogonium is organized and the female nuclei fuse in pairs. The hyphae containing the larger, or fusion-nuclei, may thus be regarded as sporophytic, the others as gametophytic.

Asci arise from the sporophytic or ascogenous hyphae. The hypha, on reaching the subhymenial layer, bends over and its two terminal nuclei undergo simultaneously a karyokinetic division in the prophase of which sixteen chromosomes may be counted. As first described by Dangeard, a terminal uninucleate and a penultimate binucleate cell are now cut off, the latter constituting the young ascus.

The terminal cell may continue its growth and give rise to a hypha, the penultimate cell of which again forms an ascus. The two nuclei of the ascus appear to be, in such cases, of the relationship of cousins.

Each of the two nuclei of the ascus now enters on the early prophases of hetero-