THE CHANGE IN DISPOSITION OF PLASTIDS AND MITOCHONDRIA DURING MICROSPOROGENESIS AND SPOROGENESIS IN SOME HIGHER PLANTS

B. RODKIEWICZ[1], J. BEDNARA[1], A. MOSTOWSKA[2], E. DUDA[1] and H. STOBIECKA[1]

[1] Institute of Biology, Maria Curie-Skłodowska University, Akademicka 19, 20-033 Lublin, Poland
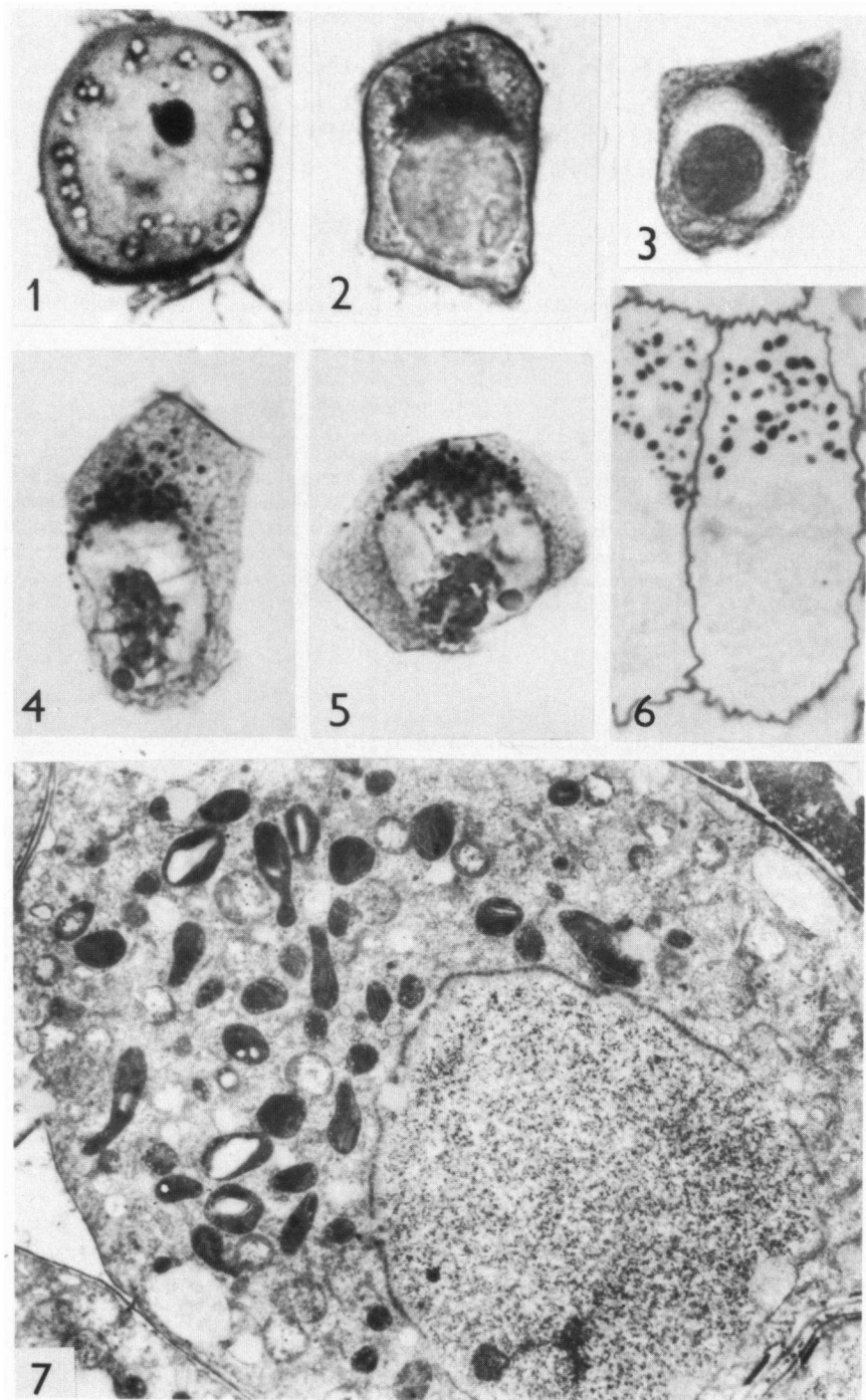[2] Department of Plant Physiology, Warsaw University

SUMMARY

In microsporocytes of *Stangeria, Impatiens* and *Tradescantia* and in sporocytes of *Equisetum* all plastids and mitochondria aggregate for a short period at one side of the early prophase I nucleus. Later the organelles disaggregate and during metaphase I and anaphase I they organelles migrate towards the equator of the cell. In *Impatiens, Clarkia, Lysimachia* and *Equisetum* all these organelles aggregate in the equatorial plane, thus dividing a dyad into two parts. After meiosis II the equatorial aggregation of organelles is reshaped and divides a tetrad into four parts. Inside the aggregation of organelles, cell plates are simultaneously set up.

1. INTRODUCTION

The behaviour of mitochondria and plastids in dividing cells has been investigated since the end of the last century (ref. BAKOWSKI 1938, RODKIEWICZ et al. 1985). During meiosis in some higher plants there is an obvious pattern of organelle migration. At early prophase I all plastids and mitochondria aggregate on one side of the nucleus and disaggregate long before the termination of prophase I. The second aggregation seems to occur only in plants where microsporogenesis or sporogenesis ends with simultaneous cytokinesis. There organelles of dyads form an equatorial aggregation which lasts until posttelophase II. This aggregation presumably prevents the coalescence of meiosis II spindles (RODKIEWICZ et al, 1985, BEDNARA et al. 1986). In the fournucleate tetrad, the organelle aggregation changes its shape and divides the cell into four parts which are finally separated by walls (RODKIEWICZ et al. 1984).

2. MATERIAL AND METHODS

Sporangia of *Equisetum hyemale* L., microsporangia of *Stangeria eriopus* (Kunze) Nash and anthers of *Impatiens balsamina* L. were fixed in 2% glutaraldehyde in 0,05 cacodylate buffer at pH 7,0 and embedded in Epon. Ultrathin sections stained with uranyl acetate and lead citrate were examined with a Tesla electron microscope. Semithin sections were stained with 2% toluidine blue or

PAS (periodic acid, Schiff reagent) for insoluble polysaccharides.

In addition, anthers of *Tradescantia virginica* L., *Clarkia elegans* Dougl. and *Lysimachia thyrsiflora* L. were fixed in a mixture of ethyl alcohol and acetic acid (3:1) or in 2% glutaraldehyde for light microscopy.

3. RESULTS

Plastids and mitochondria of early prophase I microsporocytes of *Stangeria (fig. 1), Impatiens* and *Tradescantia* and sporocytes of *Equisetum* are scattered around the nucleus. Plastids in meiocytes of these plants contain starch grains and can therefore be easily identified under a light microscope. After leptotene all plastids and mitochondria aggregate at one side of the nucleus (*figs. 2–7*), usually opposite the bouquet figure of chromosomes (*figs. 3–5*). The aggregation soon is dispersed and organelles occur again separately in the cytoplasm.

At metaphase I and telophase I in meiocytes of *Impatiens, Clarkia, Lysimachia* and *Equisetum*, all mitochondria and plastids migrate towards the equator of the cell, aggregating there in the form of a ring close to the wall. After telophase I the organelles occupy an eqatorial plane (*figs. 8, 9, 11–13* and *18–20*). The equatorial aggregation in dyads of *Impatiens* consists mainly of mitochondria, plastids and small vesicles. At some time during interkinesis it stretches across the whole cell (*fig. 8*), but at the end of interkinesis and during meiosis II it becomes thicker and is separated from the wall by a layer of cytoplasm with ER cisternae (*figs. 13* and *10*). After the conclusion of telophase II the organelle aggregation changes shape and divides a tetrad into four parts (*figs. 14–17*).

In *Equisetum* sporogenesis at metaphase II, the intermingled mitochondria and plastids are aggregated in a thin layer stretching across the whole cell (*figs. 18* and *19*). This layer gives off a weak but distinct autofluorescence (*fig. 21*). After meiosis II the organelles in the layer segregate into three strata: the middle stratum consisting of closely lying mitochondria with trapped remnants of microtubules (MTs) and the two outside strata of scattered plastids (*fig. 22*). Inside the mitochondrial layers, cell plates are formed showing strong callose fluorescence (*fig. 23*).

Figs. 1–3. Microsporocytes of *Stangeria*. Fig. 1. Early prophase I, plastids with starch grains around the nucleus × 900. Figs. 2 and 3. Plastids with starch grains (PAS) aggregated at the nucleus.

Figs. 4 and 5. Microsporocytes of *Tradescantia*, prophase I, starch grains (PAS) at the nucleus × 1.200.

Fig. 6. Sporocyte of *Equisetum*, prophase I, semithin section (PAS) × 1.200.

Fig. 7. Microsporocyte of *Stangeria*, prophase I, mitochondria and plastids at one side of the nucleus × 6.000.
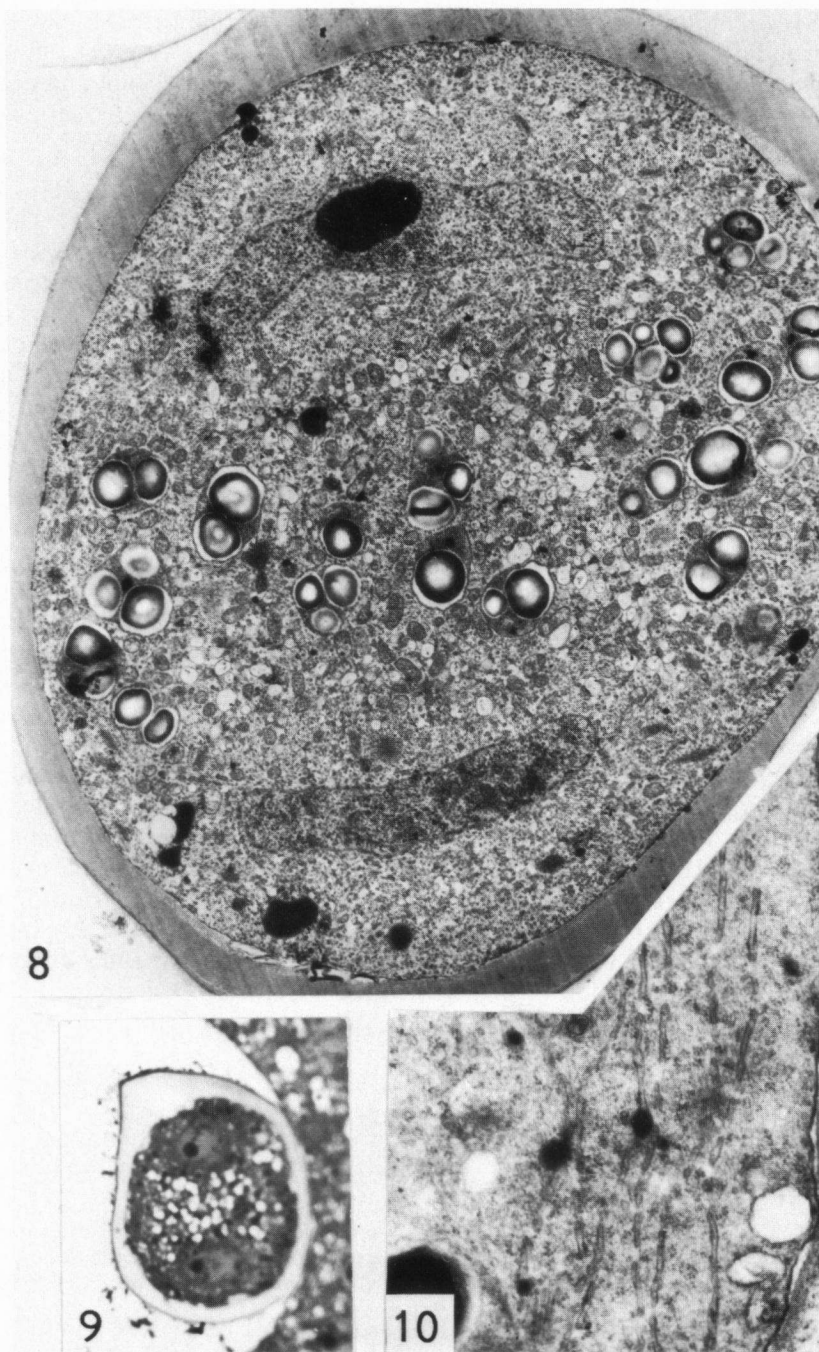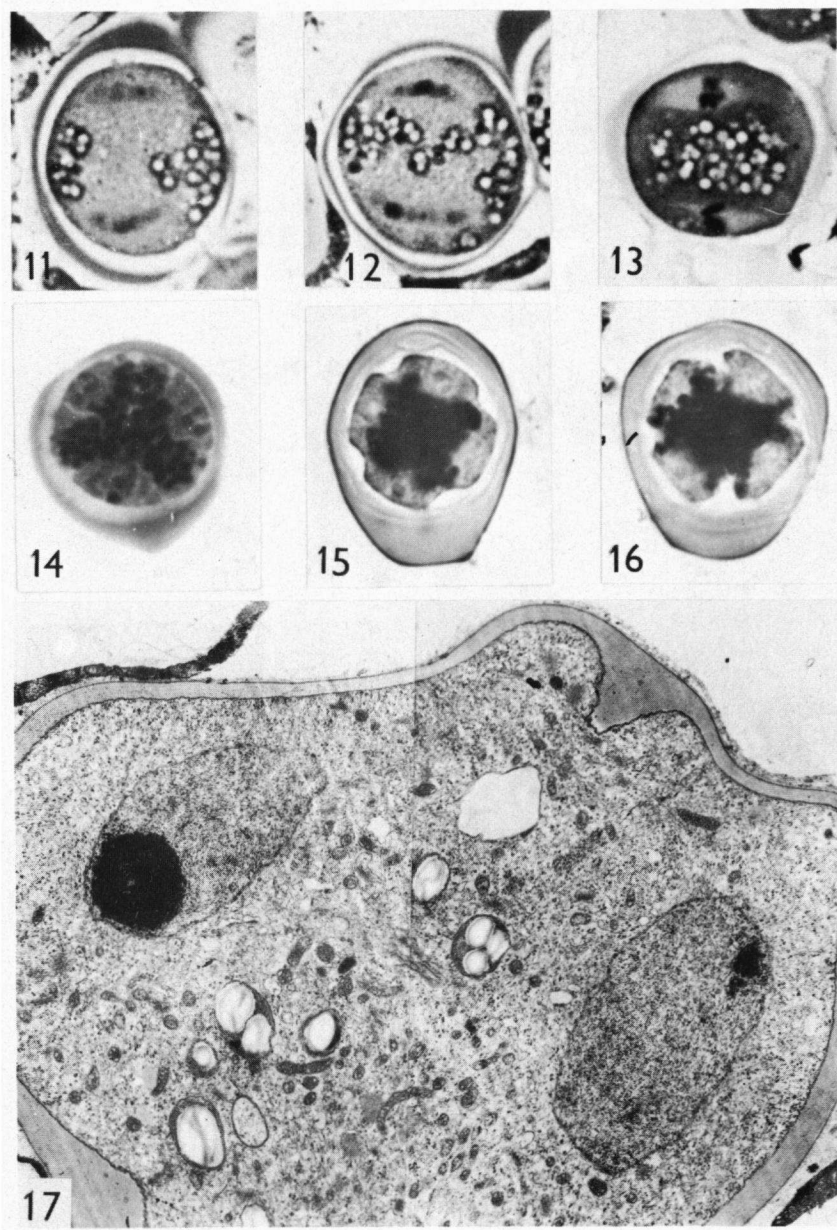
Fig. 8. Dyad of *Impatiens*, plastids, mitochondria and vesicles in an equatorial aggregation × 4.000.
Fig. 9. Dyad of *Clarkia*, aggregation of organelles, starch grains unstained, semithin section × 900.
Fig. 10. Dyad of *Impatiens*, older then in *fig. 8*, ER cisternae between the wall and organelle aggregation × 12.000.

Figs. 11–17. Microsporogenesis in *Impatiens*. Fig. 11. Organelles migrating along the equatorial plane. Fig. 12. Equatorial aggregation, dyad. Fig. 13. Metaphase II × 1.275. Figs. 14–16. Tetrads divided by aggregated organnelles, PAS × 1.190. Fig. 17. Plastids and mitochondria confined to the middle parts of the tetrad × 3.825.
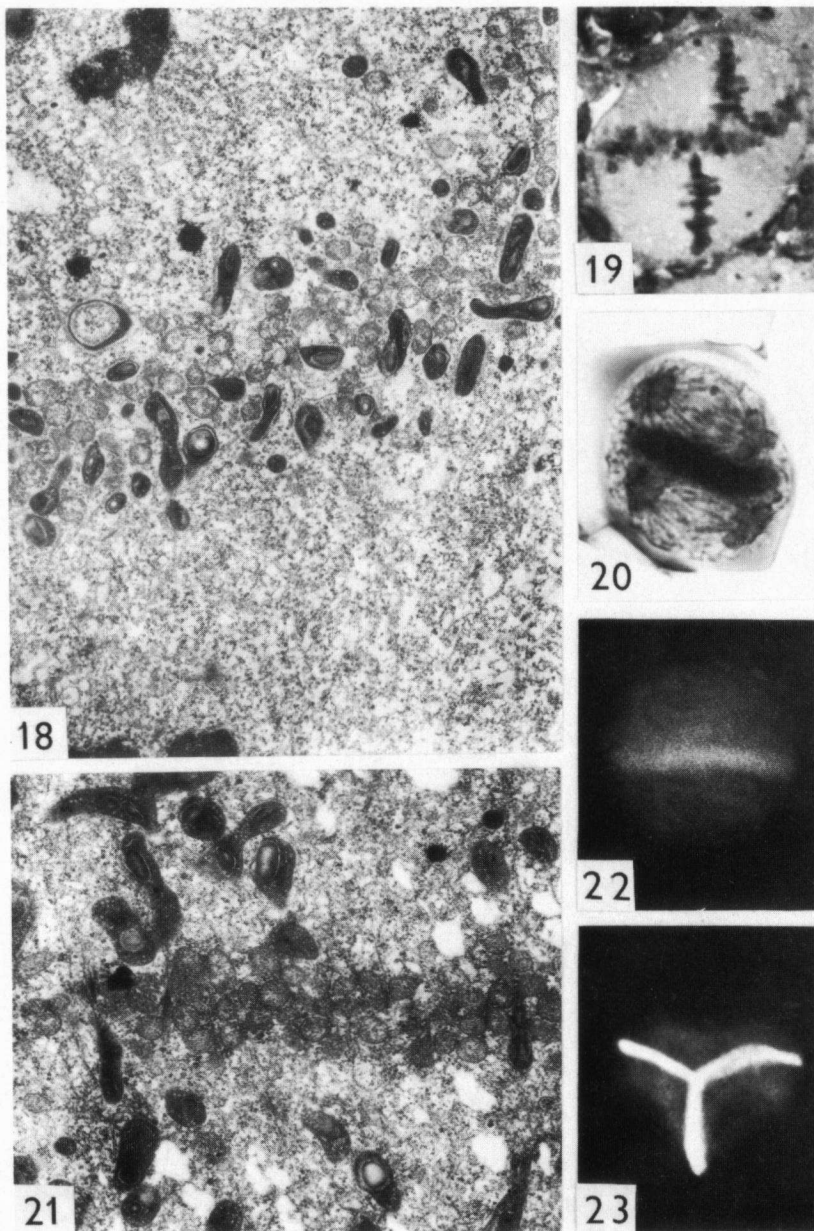
Figs. 18 and 19. *Equisetum* sporocyte, metaphase II, layer of intermingled plastids and mitochondria × 4.250 and × 935.

Fig. 20. *Lysimachia* microsporocyte, anaphase II, a layer of aggregated organelles, nigrosine stained × 1.615.

Fig. 21. *Equisetum* tetrad, organelles between sister posttelophase II nuclei. Middle mitochondrial layer with remnants of MTs, outside plastids × 5.100.

Fig. 22. *Equisetum* dyad, autofluorescence of organelle aggregation × 850.

Fig. 23. *Equisetum* tetrad, aniline blue fluorescence of callose in cell plates × 850.

4. DISCUSSION

Temporary aggregation of organelles in meiocytes occurs regularly at prophase I nucleus in widely different plants: *Equisetum, Stangeria, Impatiens, Tradescantia* and others (ref. BAKOWSKI 1938, RODKIEWICZ et al. 1985). The mechanism underlying this phenomenon remains unexplained.

The posttelophase I equatorial aggregation of organelles has been described in several species. These aggregations may differ in shape and size, e.g. in *Impatiens* dyads the aggregation is relatively thicker than in *Equisetum*. The aggregated organelles in *Equisetum* segregate into separate strata, while such segregation in *Impatiens* has not been seen.

In the period form metaphase I to posttelophase I, organelles are migrating towards the equator of the cell and aggregating around the kinetic spindle. An extensive system of MTs is also present between posttelophase I and II nuclei (VAN LAMMEREN et al. 1985). This system must disappear prior to the migration of organelles in the equatorial plane, only remnants of MTs remaining visible in the organelle aggregation (*fig. 22*).

REFERENCES

BAKOWSKI, Z. (1938): Versuch einer Klassifizierung der Chondriokinese bei Kormophyten. *Acta Soc. Bot. Pol.* 15: 323–369.

BEDNARA, J., I. GIELWANOWSKA & B. RODKIEWICZ (1986): Regular arrangements of mitochondria and plastids during sporogenesis in Equisetum. *Protoplasma* 130: 145–152.

RODKIEWICZ, B., J. BEDNARA & I. GIELWANOWSKA (1985): Changing arrangements of plastids and mitochondria in meiotic cells in higher plants. (Polish with English summary.) *Postepy Biol. Komórki* 12: 129–143.

—, K. KUDLICKA & H. STOBIECKA (1984): Patterns of amyloplast distribution during microsporogenesis in Tradescantia, Impatients and Larix. *Acta Soc. Bot. Pol.* 53: 437–441.

VAN LAMMEREN, A. A. M., C. J. KEIJZER, M. T. M. WILLEMSE & H. KIEFT (1985): Structure and function of the microtubular cytoskeleton during pollen development in Gasteria verrucosa (Mill.) H. Duval. *Planta* 165: 1–11.