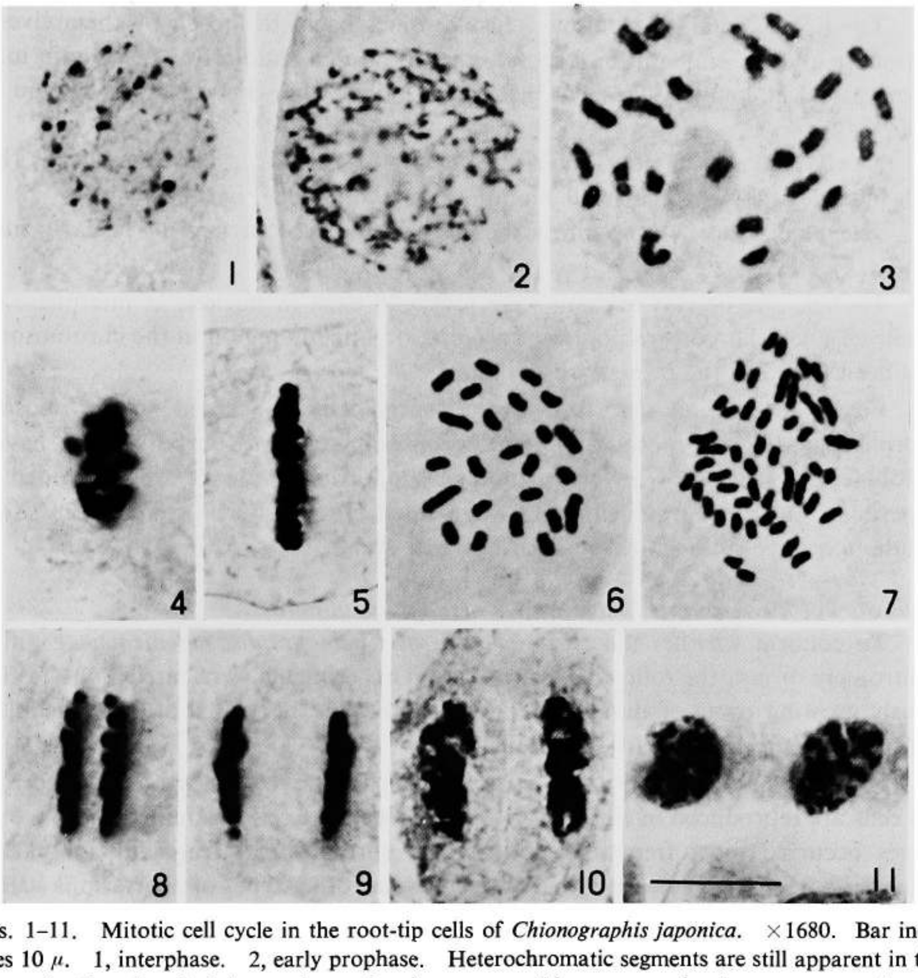
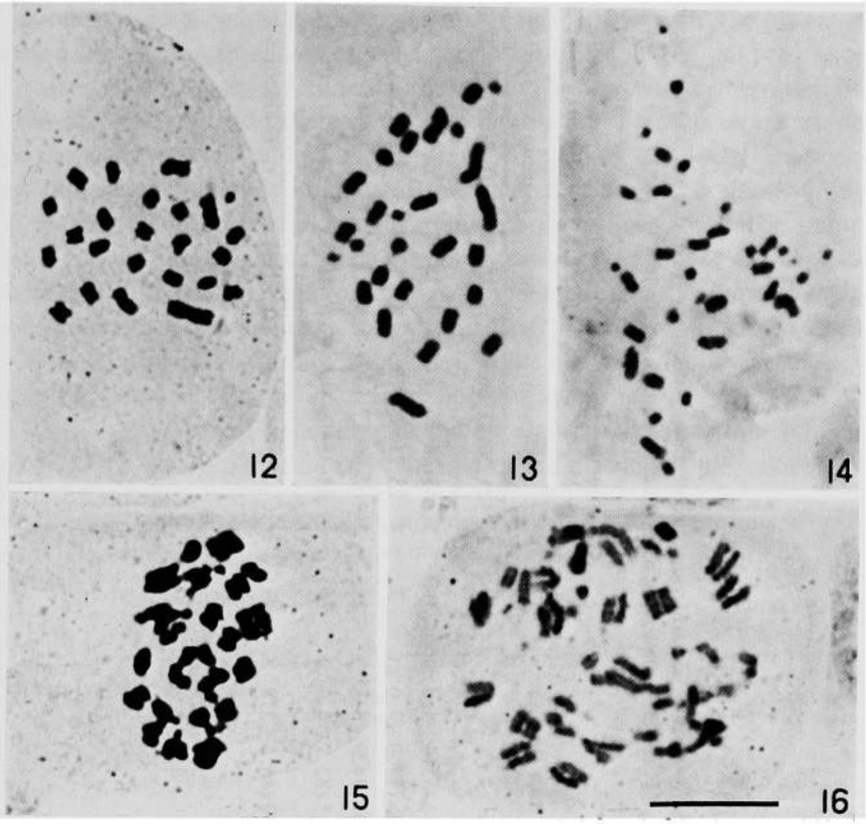
mid prophase. Eventually in mid through late prophase, this differential staining pattern was lost (Fig. 3). In some of the chromosomes at mid prophase, however, gap-like small constrictions could be seen (Fig. 3), but these constrictions became almost invisible in later mitotic stages as the chromosomes get more and more contracted. In mid and late prophase, the sister chromatids ran side by side in parallel and no region were there to be seen bilaterally linked to each other. After the disappearance of the nuclear envelope at the end of the prophase, the chromosomes migrate step by step to the equatorial plate (Fig. 4). In this pro-metaphase they are more strongly contracted and the sister chromatids lie parallel more intimately than they were at prophase.



Figs. 1–11. Mitotic cell cycle in the root-tip cells of *Chionographis japonica*. ×1680. Bar indicates 10 μ. 1, interphase. 2, early prophase. Heterochromatic segments are still apparent in the chromatin threads. 3, late prophase, showing some ambiguous gaps in chromosomes. 4, prometaphase. 5, metaphase in side view. 6, a polar view of the metaphase. 7, early anaphase, showing parallel separation of the chromosomes. 8, early anaphase in side view. 9, early telophase. 10, late telophase. 11, daughter nuclei.

In the metaphasic and anaphasic chromosomes in this species, any distinct primary constriction simulatable to that of the monocentric chromosomes could

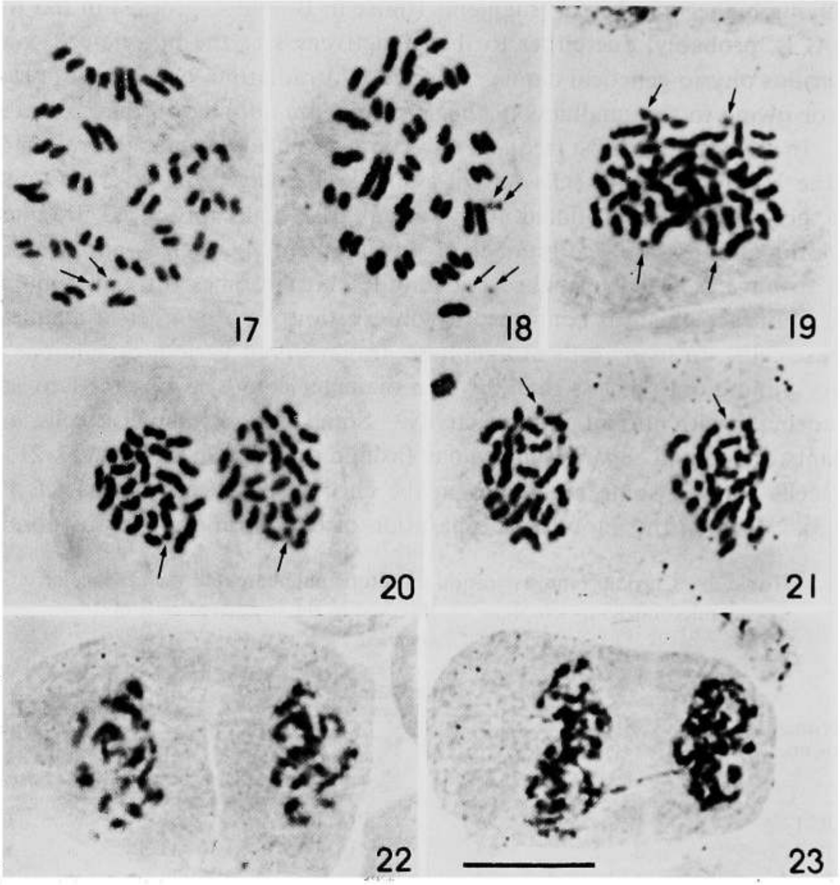
first R–1 lot, the aberrations of the chromosomes could be detected in 182 cells (85.4 ±4.0%) out of 213 cells examined. Each corresponding measures for R–2, R–3, and R–4 lots are 97.0±3.0%, 84.9±5.8%, and 82.7±6.9%, respectively. It is quite striking that such unusually high ratio of the cells including chromosomal aberrations persisted to the second (R–2), third (R–3), and to the fourth fixations (R–4). Although real scores varied in a series of 85.4%, 97.0%, 84.9%, and 82.7%, the data obtained here seem to imply that the fragments produced by the X-irradiations did survive in the subsequent generations.



Figs. 12–16. Chromosomal aberrations induced by X-ray irradiation in *C. japonica*. ×1680. Bar indicates 10 μ. 12, a cell (2n=24) with aberrant karyotype (Lot R–3). 13, a cell (2n=29) with aberrant karyotype (Lot R–4). 14, a cell (2n=39) with numerous fragments (Lot R–2). 15 and 16, cells with diplochromosomes (Lot R–3).

Meanwhile, the wide range of the variation of the diploid chromosomal numbers was found in every experimental lots (cf. Table 2). The widest range of the chromosome number was found in the second lot, R–2. Here, 2n was varied from 24 to as high as 40. This wide range of chromosome numbers was divided arbitrarily into three groups; namely, A-group with aberrant 2n=24, 25, 26, and 27; B-group with 2n=28–31; and C-group with 2n=32–40. The first A-group occupies about 80% level in the pooled measures, B-group about 18%, and C-group, about 3%. Relative frequencies in the A-group shift in the order from R–1, R–2, R–3, and R–4, as

chromosome separation at mitotic anaphase and telophase was quite normal. Almost all the fragments of the chromosomes produced by the irradiation are supposed to have underwent regular separation at mitotic stages and survived in the subsequent generations. All these observations seem to indicate clearly the presence of holokinetic features in the chromosomes of the present materials.



Figs. 17–23. Separation of chromosomes and chromosome fragments in anaphase and telophase cells in *C. japonica*. ×1680. Bar indicates 10 μ. 17 and 18, early anaphase cells showing the normal and parallel separation of the chromosomes and chromosome fragments (indicated by arrows; both Lot R-4). 19–21, mid to late anaphase cells showing the separation of the fragments (indicated by arrows; 19 and 20, Lot R-4; 21, R-3). 22, telophase showing the normal separation of chromosomes (Lot R-3). 23, telophase showing one long stretched bridge, just broken by septum newly formed (Lot R-1).

Discussion

It is obvious that the chromosomes of *Chionographis japonica* are holokinetic and fall under the category of the holocentric chromosomes, since the behavior and appearance of the chromosomes are quite in agreement with some of the known characteristic features of the holocentric chromosomes. Namely, the chromosomes