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Author(s)	MATSUURA, Hajime; SUTO, Tiharu
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# Contributions to the Idiogram Study in Phanerogamous Plants I.

By

HAJIME MATSUURA and TIHARU SUTÔ

(With Plates V-XXI)

The estimation of chromosome numbers in plants has attracted from the last decade of the last century the intense interest of plant cytologists. Up to the present, a number of plant species have been karyologically dealt with, and the data on this matter are being still more accumulated from day to day. For the magnitude of works carried out on this line in plants, one may refer to the lists of chromosome numbers made by TISCHLER (1931)<sup>1)</sup> and GAISER (1930, '33)<sup>2)</sup>.

We fear however that in earlier works uncertainty often prevails as to the number of chromosomes, causing much confusion and rendering the matter very obscure. Such uncertainty may have come partly from inadequate technique necessarily employed at that time and partly from a prejudice that kindred taxomic groups of plants should be conditioned by similar chromosome situations. For actual instances of such miscountings, it will be enough to quote that the haploid chromosome number of certain species of *Trillium* and *Paris* was reported by several authors to be 6 instead of 5 (*cf.* HAGA, 1934)<sup>3)</sup> and again in *Hosta* it has been stated from the time of STRASBURGER until quite recently to be 24 instead of 30 (*cf.* AKEMINE, 1935)<sup>4)</sup>.

On the other hand, it has been generally known that a species is composed of several karyotypes (i.e. cytological types) which may be associated with certain differences in morphological or ecological nature in some cases or not in others. One of the most striking instances was presented by the senior writer (MATSUURA, 1935)<sup>5)</sup> in *Fritillaria camschatcensis*, in

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1) TISCHLER, G., *Tabulae Biol.*, **7** (1931), 109-226.

2) GAISER, L. O., *Genetica*, **8** (1926), 401-484; *Bibl. Gen.*, **6** (1930), 171-466; *Genetica*, **12** (1930), 161-260; *Bibl. Gen.* **10** (1933), 103-250.

3) HAGA, T., *Jour. Fac. Sci., Hokkaido Imp. Univ.*, S. V, **3** (1934), 1-32, pl. I.

4) AKEMINE, T., *Journ. Fac. Sci. Hokkaido Imp. Univ.*, S. V, **5** (1935), 25-32.

5) MATSUURA, H., *Journ. Fac. Sci., Hokkaido Imp. Univ.*, S. V, **3** (1935), 219-32, pl. XIII-XIV.

which the diploid form was shown to be restricted to the alpine region, whereas the triploid form grows only at lowlands. The introduction of a conception of such a 'karyo-ecotype' will serve for the inspection of evolutionary processes within a species.

Recently, with more advances in karyological technique, the cytologists have come to realize the importance of the chromosome complement as a useful tool for grasping the more exact nature of organisms than is indicated by the number of chromosomes only. Excellent achievements have been made on this line in several different groups of plants and are to be expected in others.

The object of the present work is then to prepare exact data in phanerogamous plants concerning (i) the number, (ii) the size, and (iii) the configuration of chromosomes, and finally (iv) karyotypes, if any. For this purpose, a great many collections of living material were made from several different localities of Japan<sup>1)</sup>, and more extensive later collections are intended.

In the following descriptions, several abbreviations are employed, RT to denote root-tips, PG for pollen grains, PMC for pollen mother-cells, Cult. for cultivated<sup>2)</sup>, etc. For a given species, a presentation of the data concerning both the diploid and the haploid complements is primarily demanded. In most of the species dealt with in the present report, observations were obligatorily made only on either one or the other of them. Such insufficiencies are expected to be supplemented by further reports of this series.

*Methods.* The following methods were principally employed: (i) the ordinary paraffin method for RT and PMC, the fixatives being either TAYLOR's solution or LA COUR 2BE, (ii) the acetocarmine smear method for PMC and PG, and (iii) the permanent smear method for PMC and PG, the fixatives being the same as in (i). In all cases, the preparations were stained with gentian-violet exclusively after NEWTON's method. For brevity, these methods are represented in the figure explanations as P (for i), A (for ii) and S (for iii).

The figures in this work were drawn with ABBÉ's camera lucida, at bench level with a tube length of 160 mm., an objective 1/12 oil immersion

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1) For identity of the species names in the present study, the writers are indebted to Prof. TATEWAKI of the Hokkaido Imperial University and partly to Dr. KITAMURA of the Kyôto Imperial University, to whom the writers wish to express their sincere thanks.

2) Material from various sources in Japan and foreign countries cultivated in our experimental gardens or green-houses.

and Zeiss 20 × eyepiece, by which a magnification of 3,500 diameters was obtained. Cases where this magnification was departed from are only Figs. 42 and 150, which are magnified by 5,000.

**1. *Taxus cuspidata* Sieb. & Zucc.  $n=13_{II}(\text{♀})$ ,  $10_{II}+1_{IV}(?)$  ( $\text{♂}$ ), (PMC), Figs. 1, 2 and 3. Cult.**

The meiotic chromosomes of *Taxus* are very difficult to fix well; they readily become swollen and tend to stick together, rendering a critical study of them very hard. Pl. V, Figs. 1-3 were chosen from material in which the fixation was best, though the chromosomes in Fig. 2 are slightly swollen.

The chromosome number counted by the writers in the present material differs from those reported previously. According to STRASBURGER (1904)<sup>1)</sup> and HAWKER (1930)<sup>2)</sup> the haploid number of chromosomes in *Taxus* species is 8 and the diploid number 16, while the recent works by DARK (1932)<sup>3)</sup> and SAX & SAX (1933)<sup>4)</sup> determined  $n=12$  and  $2n=24$  in both male and female plants. The present writers observed however 13 bivalents in meiosis of PMC of intersexual plants, that is, plants bearing both male and female flowers in the same individual, which have not previously been treated (Fig. 3), and 10 bivalents plus four (probably) chromosomes associated in male plants. The special chromosomes in the latter are associated together in either a ring (Fig. 2) or chain (Fig. 1) and are a constant characteristic in every PMC of male plants, no such chromosomes being observed in intersexual ones. Such a difference in chromosomal constitution between male and intersexual plants may be possibly correlated with the sex determination in this species, and a further critical study including the morphology and number of chromosomes in the female plants and a comparison of somatic chromosomes in each sex is now in progress.

**2. *Chloranthus glaber* Makino  $2n=30$ (RT), Fig. 4. Cult.**

The somatic chromosomes of this plant show a certain extent of variation in size and shape. The insertion is subterminal in four long chromosomes of the complement, two of which are characterized by the secondary constriction on a proximal position of the long arms; four smaller ones have the insertion submedian, two smaller ones markedly subterminal, and

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1) STRASBURGER E., Denkschr. med.-naturw. Ges. Jana, 11 (1904), 1-16.

2) HAWKER, L., Ann. Bot., 44 (1930), 535-9.

3) DARK, S. O. S., Ann. Bot., 46 (1932), 965-77.

4) SAX, K. & H. J. SAX, Journ. Arnold Arb., 14 (1933), 356-74, pl. LXXV-LXXIX.

the remainder of medium size subterminal.

SUGIURA (1931)<sup>1)</sup> reports that the somatic number of this plant is 28<sup>2)</sup>.

**3. *Silene schafta* Gmel.  $n=12$ (PMC), Fig. 5. Cult.**

The meiotic chromosomes of this plant are of several different sizes. At the metaphase or early anaphase of the first division in meiosis, it was observed that in most of the cells there were 4 bivalents with 3 chiasmata, 6 with 2 chiasmata and 2 with one chiasma. The bivalent number reported here agrees with that by BLACKBURN (1928)<sup>3)</sup> for the same species.

**4. *Glaucidium palmatum* Sieb. & Zucc.  $2n=20$ (RT), Fig. 6. Mt. Moiwa, Prov. Isikari.**

The chromosomes are all small and of similar size to one another. The constrictions were shown only indistinctly and those identified appeared to be submedian. The same number of chromosomes was reported by MIYAJI (1927)<sup>4)</sup> in the same species.

**5. *Coptis japonica* Makino  $2n=18$ (RT), Fig. 10. In circa Sendai.**

The chromosomes are rather uniform in size. The insertions seem to be generally median, but are subterminal in at least 1 pair. LANGLET (1932)<sup>5)</sup> and NAKAJIMA (1933)<sup>6)</sup> have found the same somatic number and AKEMINE (1935)<sup>7)</sup> has counted  $n=9$  in the same species.

**6. *Trollium acaulis* Lindl.  $n=8$ (PG), Fig. 7. Cult.**

In a haploid complement, 4 chromosomes are submedian-inserted, one of them having a secondary constriction on a distal part of the short arm, one chromosome median-inserted and 3 chromosomes subterminal. This number corresponds to that given by LANGLET (1927)<sup>8)</sup> in the same species.

**7. *Trollium europarum* L.  $n=8$ (PG), Fig. 8. Cult.**

The chromosomes are of nearly the same size as those of *Trollium*

1) SUGIHARA, T., Bot. Mag. (Tokyo), **55** (1931), 353-5.

2) Our present results are in accordance with those obtained by YAGIZAWA (unpublished) who gave  $n=15$  and  $2n=30$  for four species of *Chloranthaceae*, *C. glaber*, *C. serratus*, *C. japonicus* and *C. spicatus*.

3) BLACKBURN, K., Verh. V Internat. Kongr. Vererb. Berlin (1928), 430-46.

4) MIYAJI, Y., Bot. Mag. (Tokyo) **41** (1927), 443-60.

5) LANGLET, O., Svensk Bot. Tids., **26** (1932), 381-400.

6) NAKAJIMA, G., Jap. Journ. Gen., **9** (1932), 1-5.

7) AKEMINE, T., Journ. Fac. Sci., Hokkaido Imp. Univ., S. V, **5** (1935), 1-7.

8) LANGLET, O., Svensk Bot. Tids., **21** (1927), 1-17.

*acaulis*, but differ in the position of the constriction. In this plant all the chromosomes have the insertion subterminal and there are neither double-constricted chromosomes nor median-inserted ones as found in *T. acaulis*. For the same species, LEWITSKY (1931)<sup>1)</sup> gives also the same chromosome number.

**8. *Trollium purpuratum***<sup>2)</sup>  $2n=18$ (RT), Fig. 9. Cult.

A certain extent of variation in chromosome size is recognizable within a complement, the longest chromosome amounting to  $4.2\mu$  in length, and the shortest to only  $2\mu$ . The chromosomes all have the insertion subterminal and can be grouped into two types, viz., one type with the short arm  $1/3$  or more the length of the long arm and the other type with the short arm conspicuously small and spherical in shape. Five pairs of a chromosome complement belong to the former type and 3 pairs to the latter.

**9. *Thalictrum aquilegifolium* L.**  $n=7$ (PMC),  $2n=14$ (RT), Figs. 11, 12 and 13. Mt. Gassan, Prov. Uzen.

The insertions of the somatic chromosomes were difficult to determine, but trabants are present in 2 apparently terminal chromosomes. The meiotic chromosomes are spherical in shape and of equal size. They are usually widely separated at the first (Fig. 11) and second (Fig. 12) metaphase, so that exact counts of them are readily made; no irregularities in meiosis has been noted. The number determined here corresponds to that counted by LANGLET (1927)<sup>3)</sup> and KUHN (1928, '29)<sup>4)</sup> in the same species.

**10. *Thalictrum yesoense* Nakai**  $n=7$ (PMC), Fig. 14. Mt. Iwate, Prov. Rikutyû.

The plates at metaphase of the first meiotic division of the PMC were not available, but those at second metaphase admit of no doubt that the gametic number is 7. The chromosomes are all of similar size, and closely resemble those of the preceding species.

**11. *Anemone japonica* Sieb.**  $2n=16$ (RT), Fig. 15.

The somatic chromosomes in a complement are grouped into three

1) LEWITSKY, G. A., Bull. App. Bot., Gen. Pl.-Breed., **27**(1931), 187-240, pl. II-XI.

2) The author name could not be traced.

3) LANGLET, F., Svensk Bot. Tids., **21**(1927), 1-17 and 397-422.

4) KUHN, E., Jahrb. wiss. Bot. **68**(1928), 382-430, pl. XII. and Ber. Deu. Bot. Ges. **47**(1929), 420-30.

types, according to the position of insertions, namely, (i) 3 pairs median, (ii) 2 pairs submedian and (iii) 3 pairs subterminal. Among subterminal-inserted chromosomes, one pair is satellited. For the same species, TAKAMINE (1916)<sup>1)</sup>, NAKAJIMA (1932)<sup>2)</sup> and MOFFETT (1932)<sup>3)</sup> determined  $2n=16$ , and MOFFETT reported also that the haploid number is 8. Their statement as to the chromosome number in this plant is therefore confirmed here, although they have not noticed any such satellite chromosomes as observed in the present material.

**12. *Anemone flaccida* Fr.Schm.  $n=7$ (PG), Fig. 16. Mt. Sapporodake, Prov. Isikari.**

Six chromosomes of a haploid complement are median-inserted, 2 of which evidently have the insertion submedian. In addition to these, there is one chromosome with subterminal insertion and having a satellite. NAKAJIMA (1933)<sup>4)</sup> found the diploid number to be 14, but in his figure no trivalent is shown.

**13. *Hepatica triloba* Choix. var. *obtusa* Alph. Wood.  $2n=14$  (RT), Fig. 17. Is. Sado, Prov. Etigo.**

The somatic chromosomes of this plant are fairly large, and in 4 pairs the insertion is median, in 2 pairs submedian and in one pair subterminal. The last pair is characterized by the presence of a large satellite on each member.

According to MOFFETT (1932)<sup>3)</sup>, in *Anemone Hepatica* (= *Hepatica triloba*) there are not only a diploid form with a basic number of 7, but also frequently an aneuploid form having 16 somatic chromosomes owing to somatic doubling of chromosomes. Likewise SUGIURA (1931)<sup>4)</sup> observed 16 somatic chromosomes in *Hepatica triloba* var. *acuta*. NAKAJIMA (1933)<sup>5)</sup> reported 14 diploid number in this species as in our observations, though no satellite chromosomes were shown in his figure. According to LANGLET (1927)<sup>6)</sup>, two other species of *Hepatica*, *H. acutiloba* and *H. angulosa*, have 14 diploid chromosomes.

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1) TAKAMINE, N., Bot. Mag. (Tokyo), **30** (1916), 293-303.

2) NAKAJIMA, G., Bot. Mag. (Tokyo), **45** (1931), 7-11.

3) MOFFETT, A. A., Cytologia, **4** (1932), 26-37.

4) SUGIHARA, T., Bot. Mag. (Tokyo), **45** (1931), 353-5.

5) NAKAJIMA, G., Jap. Journ. Gen., **9** (1933), 1-5.

6) LANGLET, O., Svensk Bot. Tids., **21** (1927), 1-17.

**14. *Pulsatilla cernua* Spring  $2n=16$ (RT), Fig. 18. Mt. Zaô, Prov. Uzen.**

The chromosome complement of this species may be distinguished into the following six classes; (i) one pair, ca.  $9\mu$  in length with submedian insertions, (ii) one pair ca.  $6-7\mu$  long with median insertions, (iii) one pair ca.  $7\mu$  long with submedian insertions and characterized by a very small satellite on the distal end of the long arms, (iv) two pairs ca.  $6\mu$  long with submedian insertions, (v) two pairs ca.  $5.5\mu$  long with subterminal insertions, and (vi) one pair ca.  $4.5\mu$  long with subterminal insertions and a satellite attached to the distal end of the short arms.

The chromosome number in the present material agrees with that reported by LANGLET (1927 for *P. albana*, *A. georgica* and *P. armena*)<sup>1)</sup> and by NAKAJIMA (1931 for *P. cernua*)<sup>2)</sup>, though they did not notice any satellited chromosome.

**15. *Trautvetteria japonica* Sieb. & Zucc.  $n=8$ (PMC), Fig. 20. Mt. Daisetū, Prov. Isikari;  $2n=16$ (RT), Fig. 19. Mt. Gassan, Prov. Uzen.**

This species closely resembles *Thalictrum* in characters of the flower and in the inflorescence, but karyologically it differs clearly from the latter by having much larger chromosomes, of which all the members can be identified not only in somatic divisions but also with some degree of certainty in meiosis. Four pairs have the insertions median while the remaining 4 subterminal. In the somatic complement, the former are designated in the order of size as A (ca.  $10\mu$ , median), B (ca.  $9\mu$ ), C (ca.  $8\mu$ , somewhat submedian) and D (ca.  $7\mu$ , median), and the latter E (ca.  $7\mu$ ), F (ca.  $6\mu$ ), (with the short arm of rod shape), G (ca.  $5\mu$ , with a spherical short arm) and H (ca.  $4.5\mu$ , having a knob-like arm furnished with a satellite).

LANGLET (1927)<sup>1)</sup> reported that the diploid number in *Trautvetteria palmata* is 28.

**16. *Ranunculus acris* L. var. *Steveni* Regel  $2n=14$ (RT), Fig. 22. Mt. Hakkôda, Prov. Mutu.**

The following chromosome types can be distinguished within a complement; (i) one longest pair (ca.  $11\mu$ ) with median insertion, (ii) 2 long

1) LANGLET, O., Svensk Bot. Tids., 21 (1927), 1-17.

2) NAKAJIMA, G., Bot. Mag. (Tokyo), 45 (1931), 7-11.

pairs (ca.  $7\mu$ ) with submedian insertions, (iii) 2 medium long pairs (ca.  $6\mu$ ) with subterminal insertions, (iv) one medium long pair (ca.  $5.5\mu$ ) with subterminal insertion, and (v) one short pair (ca.  $4\mu$ ) with subterminal insertions. In the latter two, the shorter arms are spherical in shape, while in type (iii) they are rod-shaped.

The chromosome number determined here for this species is in accordance with that reported by MIYAJI (1927)<sup>1)</sup> and LANGLET (1927)<sup>2)</sup>.

**17. *Ranunculus acris* var. *frigidus* Regel  $n=7$ (PG), Fig. 21. Cult.**

The chromosomes resemble those of the preceding variety, but there seem to exist 3 chromosomes with nearly terminal insertions instead of 2 chromosomes in the latter.

**18. *Ranunculus bulbosus* L.  $n=7$ (PG), Fig. 23. Cult.**

The present material was obtained from seeds which had been sent to us from Botanic Garden of Delft under this name, but it is doubtful whether this material is to be referred to this species or to any other. LANGLET (1927)<sup>2)</sup> dealing with this species and its 4 varieties found the diploid number to be 16 which is not in accordance with the writers' present results. The chromosome complement resembles that of *R. acris*, but 2 chromosomes are very long and have median insertions.

**19. *Ranunculus Flammula* L.  $2n=32$ (RT), Fig. 24. Cult.**

The diploid number 32 suggests that this species is of a tetraploid nature with the basic number 8. A chromosome complement consists of 8 chromosomes having the insertion median, 4 submedian and 20 subterminal. In the former two types, 4 chromosomes each are very long, and in one or two chromosomes of the second type a small satellite is frequently observed on the distal end of their long arms. Within the subterminal chromosomes, several different sizes of the short arm are distinguishable; roughly classified, 12 chromosomes have a knob-like arm and the other 8 a rod-shaped one.

As in our observations, LANGLET (1927)<sup>2)</sup> reported  $2n=32$  in the same species.

**20. *Ranunculus hakkodensis* Nakai  $2n=16$ (RT), Fig. 25. Mt. Hakkôda, Prov. Mutu.**

1) MIYAJI, Y., Bot. Mag. (Tokyo), **41** (1927), 443-60.

2) LANGLET, O., Svensk Bot. Tids., **21** (1927), 1-17.

One pair of a complement is characterized by the submedian insertion, a secondary constriction and a small satellite which is often difficult to detect. Six chromosomes have the insertion nearly median and the other 8 subterminal. Of the latter type one pair is provided with a satellite. The idiogram of this species is closely similar to that of *Pulsatilla cernua* (cf. No. 14), though it is hard to find out any connection in outer morphological characteristics between these two species.

**21. *Ranunculus Vernyi* Fr. & Sav.  $2n=16$ (RT), Fig. 26.** Kamakura, Prov. Sagami.

Most chromosomes of a complement generally have subterminal insertions, although the short arms are variable in size. One pair is evidently median-inserted. There is also one pair which is conspicuously asymmetric in the position of insertion and is furnished with a satellite.

**22. *Ranunculus Kernerii* Frey.  $2n=28$ (RT), Fig. 27.** Cult.

In this species, 12 chromosomes of a complement have the insertion median, 4 submedian and 12 subterminal. It will be inferred from this that the present material is of a tetraploid nature with the basic number 7.

**23. *Ranunculus repens* L.  $2n=32$ (RT), Fig. 28.** Cult.

In general, the complement of this species resembles that of *R. Flammula*, save that the chromosomes are slightly longer and there are 4 chromosomes median-inserted instead of 8, thus resulting in an increase by 4 in the number of subterminal chromosomes.

LANGLET (1927)<sup>1</sup> also gives the same somatic number for this species.

**24. *Ranunculus repens* var. *major* Nakai  $n=6$ (PG), Fig. 29.**

In circa Sapporo, Prov. Isikari.

The chromosomes of this variety resemble those of the preceding species, except that one of them appears to be terminal-inserted.

**25. *Ranunculus quelpaertensis* Nakai  $2n=16$ (RT), Fig. 30.** Mt. Gassan, Prov. Uzen.

The material used was obtained from an alpine boggy region (ca. 1800 m. s. m.), and it is not certain whether this specific name is available or not for the present material. Its chromosomes very closely resemble those of *Ranunculus Vernyi* in their size and shape, except that there are 4

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1) LANGLET, O., Svensk Bot. Tids., 21 (1927), 1-17.

chromosomes median-inserted, 2 of which are much smaller than the corresponding ones of *R. Vernyi*.

**26. *Ranunculus* sp.  $n=14$ (PG), Fig. 31. Saghalien.**

The material used is characterized by vigorous growth habit, glabrous herbage, well-developed stolones, etc. It resembles *R. repens*, but is distinguishable from the latter by having stolones bearing special leaves. Karyologically these two species also differ from each other, *R. repens* having 16 haploid chromosomes, but the present material 14 chromosomes as in *R. Kernerii*. The idiogram of the present species consists of 10 chromosomes submedian or median and 4 subterminal.

**27. *Diphylleia Grayi* Fr. Schm.  $n=6$ (PMC), Figs. 32, 33, 34 and 35. Mt. Moiwa, Prov. Isikari.**

In the present material, 6 bivalents usually appear at the first meiotic metaphase (Fig. 35); frequently however 4 bivalents and 4 univalents are met with (Fig. 34), a condition probably caused by precocious disjunction of two bivalents. The figures at the second metaphase (Fig. 32) and anaphase (Fig. 33) suggest that a complement consists of two pairs each of median, submedian and subterminal chromosomes.

The chromosome number established here for this species agrees with the diploid number,  $2n=12$ , found by LANGLET (1928)<sup>1)</sup> for *Diphylleia cymbra*.

**28. *Achys japonica* Maxim.  $n=6$ (PG), Fig. 36. Mt. Sapporo-dake, Prov. Isikari.**

A haploid complement consists of 6 long chromosomes which are nearly of equal size, though 2 of them are distinctly longer and only one distinctly shorter than the others. In most of them the insertion is submedian, but in the shortest one it is subterminal.

**29. *Caulophyllum robustum* Maxim.  $n=8$ (PG and PMC), Figs. 37 and 38. Mt. Moiwa, Prov. Isikari.**

The 8 chromosomes of the haploid complement are all of large size; two of them have the insertion subterminal and the others submedian. Some of the submedian chromosomes are provided with secondary constrictions on their long arms. The meiotic divisions take place in normal

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1) LANGLET, O., Svensk, Bot. Tids., 22 (1928), 169-84.

fashion. The bivalents at the first metaphase have one or two chiasmata.

The diploid number, 16, of this species has been recorded by LANGLET (1928)<sup>1)</sup>.

**30. *Dicentra pusilla* Fr. & Sav.  $n=8$ (PMC), Figs. 41 and 42.  
Mt. Iwate, Prov. Mutu.**

The meiotic chromosomes are of nearly equal size and 2 of them appear often to associate very closely in the first metaphase (Fig. 41).

The present finding agrees with that reported by SAKAI (1934)<sup>2)</sup> who counted 16 chromosomes in the root-tips of the same species. It will be of interest to note here that in another species of *Dicentra*, *D. spectabilis*, which has the same chromosome number, the senior writer (1935)<sup>3)</sup> has found a similar secondary association of two bivalents at the first meiotic metaphase (Figs. 30 and 40).

**31. *Cochlearia oblongifolia* DC.  $n=7$ (PMC), Figs. 43 and 44.  
Akkesi, Prov. Kusiro.**

The 7 bivalents are of nearly equal size. Here the secondary association of bivalents is noticeable.

**32. *Barbarea hondoense* Nakai  $n=8$ (PMC), Figs. 45, 46 and 47.  
Mt. Gassan, Prov. Uzen.**

**33. *Barbarea patens* Boiss.  $n=8$ (PMC), Fig. 48. Mt. Sapporo-dake, Prov. Isikari.**

These two species of *Barbarea* resemble each other so closely in the size and shape of meiotic chromosomes that no demarcation between them can be drawn. Secondary association of some bivalents is one of the characteristics of meiosis in these species.

For *Barbarea praecox*, JARETZKY (1932)<sup>4)</sup> also gave  $n=8$ , as in the present findings.

**34. *Arabis iwatensis* Makino  $n=16$ (PMC), Fig. 49. Mt. Iwate, Prov. Mutu.**

The plates at the first meiotic metaphase suggest that the complement

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1) LANGLET, O., Svensk Bot. Tids., **22** (1928), 169-84.

2) SAKAI, K., Jap. Journ. Gen., **9** (1934), 226-30.

3) MATSUURA, H., Journ. Fac. Sci., Hokkaido Imp. Univ., S. V, **3** (1935), 251-60, pl. XVIII.

4) JARETZKY, R., Jarb. wiss. Bot., **76** (1932), 485-527.

consists of 8 pairs of apparently identical chromosomes. Some of them are closely associated in pairs. Most probably this species is of a tetraploid nature, as JARETZKY (1928, '32)<sup>1)</sup> found that the basic number of *Arabis* is 8.

**35. *Saxifraga mutabilis* Koidz.  $2n=22$  (RT), Fig. 51. Mt. Teine, Prov. Isikari.**

The somatic chromosomes of the complement are all of small size, but vary considerably in length. The insertions are not evidently visible but these seem generally to be median, except at least 3 pairs which are of the smallest type and appear to lack the insertions.

According to SCHOENNAGEL (1931)<sup>2)</sup> who studied the chromosome number in 15 species of *Saxifraga*, there are 7 species with 14 haploid chromosomes, 6 species with 16 and only one species with 11 which is in agreement with our finding in the present species.

**36. *Saxifraga sachalirensis* Fr. Schm.  $n=20$  (PMC), Fig. 50. Mt. Daisetū, Prov. Isikari.**

The chromosome number of this species has already been counted by SAKAI (1934)<sup>2)</sup> who, however, gave  $n=16$ , differing from our finding. All bivalents are spherical and their meiotic divisions are normal. The present material presents a new instance of chromosome number in this genus.

**37. *Chrysosplenium flagelliferum* Fr. Schm.  $n=12$  (PMC), Figs. 52 and 53. Mt. Moiwa, Prov. Isikari.**

One of the 12 bivalents observed at the first meiotic metaphase is much larger than the rest.

SCHOENNAGEL (1931)<sup>2)</sup> found  $n=21$  in *Chrysosplenium oppositifolium*.

**38. *Tiarella polyphylla* D. Don  $n=9$  (PMC), Fig. 54. Mt. Soranuma-dake, Prov. Isikari.**

The present finding,  $n=9$ , does not stand in agreement with that by SCHOENNAGEL (1931)<sup>2)</sup> who reported  $2n=14$  for the same species. This may bear certain connection with apparent secondary association of some bivalents observed in the present material.

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1) JARETZKY, R., Jahrb. wiss. Bot. **68** (1928), 1-45; l. c., **76** (1932), 485-527.  
 2) SCHOENNAGEL, E., Bot. Jahrb. **64** (1931), 266-308.  
 3) SAKAI, K., Jap. Journ. Gen. **9** (1934), 226-30.

- 39. *Parnassia palustris* var. *multiseta* Ledeb.  $2n=18$ (RT), Fig. 55. Mt. Zawô, Prov. Uzen.**

The somatic chromosomes of the complement are of unequal size. The insertions are not conspicuous. PACE (1912)<sup>1)</sup> reported the haploid number of *Parnassia palustris* to be 10.

- 40. *Hydrangea paniculata* Sieb. var. *praecox* Rehder  $n=18$  (PMC), Fig. 56. Mt. Moiwa, Prov. Isikari.**

The meiotic complement consist of 18 bivalents of similar size, usually two of which, less frequently 3 or 4 are closely associated.

According to SAX (1931)<sup>2)</sup> and SCHOENNAGEL (1931)<sup>3)</sup>, the basic number of this genus is 18 which is in accordance with our counting in the present material.

- 41. *Schizoprogma hydrangeoides* Sieb. & Zucc.  $n=14$ (PMC), Fig. 57. Mt. Zao, Prov. Uzen.**

There is little difference in size of the meiotic chromosomes from each other within a complement as in those *Hydrangea paniculata* var. *praecox*. SAX (1931) also gives the same chromosome number for this species.

- 42. *Sanguisorbia albiflora* Makino  $2n=54$ (RT), Fig. 58. Mt. Gas-san, Prov. Uzen.**

The somatic chromosomes are slender, and vary only slightly in length. The constrictions are not conspicuous. For *Sanguisorbia hakusanensis*, SAKAI (1935)<sup>4)</sup> reports 28 chromosomes as the diploid number.

- 43. *Amorpha fruticosa* L.  $n=19$ (PMC), Fig. 59. Cult.**

The 19 bivalents of the complement are all of spherical shape and vary in their size to certain extent. Secondary association of bivalents of various degrees is indicated at the first and second metaphase of meiosis.

- 44. *Oxalis japonica* Fr. & Sav.  $2n=35$ (RT), Fig. 60. Mt. Hakkôda, Prov. Mutu.**

The somatic chromosomes in the complement vary considerably in length, the longest ones attaining ca.  $6\mu$  while the shortest ones are  $1/4$  the

1) PACE, L., Bot. Gaz., 54 (1912), 306-39, pl. XIV-XVII.

2) SAX, K., Journ. Arnold Arb., 12 (1931), 198-206, pl. XXXVII.

3) SCHOENNAGEL, E., Bot. Jahrb., 64 (1931), 266-308.

4) SAKAI, K., Jap. Journ. Gen., 11 (1935), 68-73.

length of the former. Twenty-one are long; 7 of them have the insertions submedian, and the rest subterminal. The others are short; 7 of them have the insertions submedian and the other 7 subterminal. No satellite chromosomes were observed. From these findings it may be inferred that the present material is of a pentaploid nature, the basic number being 7.

In a number of *Oxalis* species, HEITZ (1927)<sup>1)</sup> has ascertained the same basic number of chromosomes.

**45. Euphorbia splendens Boj.  $n=20$ (PMC), Fig. 61. Cult.**

The haploid number determined here differs from that reported by WENIGER (1917)<sup>2)</sup>, that is  $n=12$ . There is no indication of irregularities in the meiotic divisions in the present material.

**46. Hypericum senanense Maxim.  $2n=16$ (RT), Fig. 62. Mt. Zaô, Prov. Uzen.**

The somatic complement consists of 7 pairs of chromosomes having median or submedian insertions and 1 pair having a subterminal insertion. In one chromosome of the latter a satellite was visible on its short arm.

The haploid number 8 has been previously reported for some other species of *Hypericum* by several workers, such as NIELSON-NIELS (1924)<sup>3)</sup>, WINGE (1925)<sup>4)</sup>, CHATTAWAY (1926)<sup>5)</sup> and HOAR & HAERTL (1932)<sup>6)</sup>.

**47. Opuntia polycantha Haw.  $n=11$ (PMC), Fig. 63. Cult.**

The 11 bivalents of the complement are of nearly equal size. In the first and second metaphase of meiosis, two pairs of them tend to associate together, as shown in the figure. This will be of interest in connection with the fact that in some species of related genera (*Neomammelia macdougallii* and *Zygocactus truncata*) the haploid number was found to be 9.

STOCKWELL (1935)<sup>7)</sup> reports a tetraploid ( $2n=44$ ) and a hexaploid ( $2n=66$ ) form in this species.

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- 1) HEITZ, E., Abhandl. Gebiete Naturw. Hamburg, **21** (1927), 45-57, pl. VIII.
  - 2) WENIGER, W., Bot. Gaz., **63** (1917), 266-81, pl. XIV-XVI.
  - 3) NIELSON-NIELS, Hereditas, **5** (1924), 378-82.
  - 4) WINGE, O., La Cellule, Vol. Jubilaire **5** Grégoire (1925), 306-24.
  - 5) CHATTAWAY, M. N., Br. Journ. Exp. Biol., **3** (1926), 141-3.
  - 6) HOAR, C. S. & HAERTL, E. J., Bot. Gaz., **39** (1932), 199-204, pl. I.
  - 7) STOCKWELL, D., Bot. Gaz., **96** (1935), 567-70.

**48. *Daphne jezoensis* Maxim.  $2n=18$ (RT), Fig. 64. Mt. Teine, Prov. Isikari.**

All the individual chromosomes of the complement can be distinguished, by their relative length, the position of the insertion and presence or absence of the satellite. Four pairs have the insertions median, one of which bears a small satellite; five pairs subterminal, three of them having the short arms rod-shaped and the other two pairs spherical-shaped. One pair of the last possesses a satellite on the short arms.

In another species of *Daphne*, STRASBURGER(1906)<sup>1)</sup> found the haploid number to be 9, and in still other two species, OSAWA (1913)<sup>2)</sup> gave the diploid counts of 18 and 28 respectively.

**49. *Melastoma sanguineum* Sims.  $2n=56$ (RT), Fig. 65. Cult.**

The somatic chromosomes of the complement are all very small in size, most of them being less than  $1\mu$  in length.

**50. *Panax japonicum* C. A. Mey.  $n=24$ (PMC), Fig. 66. Mt. Moiwa, Prov. Isikari.**

The chromosomes are spherical and slightly non-uniform in size. There are certainly evidences of secondary associations of bivalents. If the present material is tetraploid, the chromosome number 24 agrees with  $n=12$  which is mostly common to *Araliaceae* (WANSCHER, 1935)<sup>3)</sup>.

**51. *Ligusticum japonicum* Maxim.  $2n=22$ (RT), Fig. 67. Mt. Iwate, Prov. Mutu.**

The chromosomes are of nearly equal size, and have usually submedian or median insertions, but in at least one pair the insertion is extremely subterminal.

The 22 chromosome number is of usual occurrence in *Umbelliferae* (cf. WANSCHER<sup>3)</sup> and TAMAMSCHIAN<sup>4)</sup>).

**52. *Cnidium ajaense* Drude  $n=12$ (PMC), Fig. 68. Mt. Daisetu, Prov. Isikari.  $2n=24$ (RT), Fig. 69. Mt. Tyôkai, Prov. Uzen.**

The haploid 12 and the diploid 24 chromosome number has not been previously known in the family *Umbelliferae*. Secondary association of

1) STRASBURGER, E., Hist. Beitr., 7 (1909), 1-124, pl. I-III.

2) OSAWA, J., Journ. Coll. Agr. Univ. Tokyo (1913), 1-264, pl. XXV-XXVII.

3) WANSCHER, J. H., Hereditas, 15 (1931); Bot. Tidskrift, 42 (1933), 42-58 and 389-99; New Phyt. 33 (1935), 58-65 and 101-26.

4) TAMAMSCHIAN, S., Bull. Apl. Bot., Gen. Pl.-Breed., 8, 2 (1933), 137-64.

some bivalents is frequently met with at the first meiotic metaphase, indicating that the basic number will be less than 12. This agrees with the assumptions made by WANSCHER (1935)<sup>1)</sup> that the primary number of chromosomes in *Umbelliferae* will be probably 8.

**53. *Heracleum lanatum* Michx.**  $n=11+1f.$ (PMC), Fig. 70. Mt. Moiwa, Prov. Isikari.

The 11 bivalents of the complement are of nearly equal size. In addition to them a fragment was always visible which behaves at random during the first meiotic division. Secondary association of bivalents is marked, and sometimes five groups of two pairs each and a single bivalent constitute the metaphasic plate, as seen in Fig. 70.

**54. *Primula Fauriae* Franch.**  $n=9$ (PG),  $2n=18$ (RT), Figs. 71 and 72. Prov. Hidaka.

**55. *Primula jesoana* Miq.**  $n=12$ (PG), Fig. 73 and 74. Kuttara, Prov. Isikari.

**56. *Primula kisoana* Miq.**  $2n=24$ (RT), Fig. 76. Cult.

**57. *Primula Sieboldii* Morr.**  $n=12$ (PG), Fig. 75. Tomakomai, Prov. Iburi.

In these species, the chromosomes are practically all of nearly equal size and closely similar in size and form to one another. The chromosomes in pollen grains of *P. Fauriae*, however, seem to be distinguishable from those of the other species by having their ends pointed rather sharply. In *P. kisoana*, the diploid complement contains a pair provided with a satellite which was not visible in the other species. In one pollen grain of *P. jesoana*, an extra fragmental chromosome was found (Fig. 74).

INUMA (1926)<sup>2)</sup> and BRUUN (1930, '32)<sup>3)</sup> find  $n=9$  and  $2n=18$  for *P. Faurie*, and these authors and NAKAJIMA (1931)<sup>4)</sup> give  $2n=24$  for *P. Sieboldii*. Likewise the triploid forms found in *P. Sieboldii* by INUMA (1926)<sup>2)</sup> and ONO (1927)<sup>5)</sup> are in agreement with the number reported here.

1) WANSCHER, J. H., New phyt. **33** (1935), 101-26.

2) INUMA, M., Sci. Rep. Tohoku Imp. Univ. S. IV-2 (1926), 189-95.

3) BRUUN, H. G., Svensk Bot. Tids., **24** (1930), 468-75, and Sym. Bot. Upsalienses, **1** (1932), 1-239.

4) NAKAJIMA, G., Bot. Mag. (Tokyo), **45** (1931), 7-11.

5) ONO, T., Bot. Mag. (Tokyo), **41** (1927), 601-4.

58. **Cortusa Matthioli L.**  $n=12$ (PMC), Fig. 77. Mt. Teine, Prov. Isikari.

The meiotic chromosomes are all similar to one another and resemble those of *Primula*. No irregularities were found in the meiotic divisions.

59. **Ligustrum yesoense Nakai**  $n=23$ (PMC), Fig. 78. In circa Sapporo, Prov. Isikari.

The meiotic chromosomes are rather small and vary somewhat in length, resembling those in other members of *Ligustrum* studied by SAX and ABE (1932)<sup>1)</sup>. For 2 other species of *Ligustrum*, SUGIURA (1931)<sup>2)</sup> gives however 22 in haploid and 44 in diploid number of chromosomes respectively, and for another species O'MARA (1930)<sup>3)</sup> gives  $n=24$ .

60. **Menyanthes trifoliata L.**  $n=27?$ (PMC), Fig. 79. Numanohata, Prov. Isikari.

Owing to scarcity of preparations, the exact number of chromosomes in this material could not be determined, as the chromosomes at the first meiotic metaphase of PMC seemed to show the appearance of univalents.

61. **Fauria Crista-galli Makino**  $2n=68$ (RT), Fig. 80. Mt. Hakôda, Prov. Mutu.

The somatic chromosomes of the complement are all small, bent distinctly and they vary in size. No satellited chromosomes exist. Most of the chromosomes show very slightly pronounced median or submedian insertions.

62. **Lithospermum Zollingeri A. DC.**  $2n=16$ (RT), Fig. 81. Kamakura, Prov. Sagami.

The somatic chromosomes of the complement are similar in size to one another and are distinguishable into three types, 2 pairs of median-inserted chromosomes, 2 pairs of submedian-inserted ones and 4 pairs of subterminal ones.

STERY (1931)<sup>4)</sup> reports  $n=14$ ,  $2n=28$  and  $2n=24$  in other four species of *Lithospermum*. The present finding adds therefore a new chromosome number to this genus.

1) SAX, K. & E. C. ABE, Journ. Arnold Arb., **13** (1932), 37-48.

2) SUGIURA, T., Bot. Mag. (Tokyo), **45** (1931), 353-5.

3) O'MARA, J., Journ. Arnold Arb., **11** (1930), 14-15.

4) STERY, M., Planta, **14** (1931), 677-730.

**63. *Solanum grandiflorum* Hort.  $2n=24$ (RT), Fig. 82. Cult.**

The chromosome number of this species which is shrubby in habit agrees with that of herbaceous *Solanum* investigated by many workers (cf. GAISER 1926, '30, '32)<sup>1)</sup>. The chromosomes have clear insertions which are subterminal in 16 chromosomes and submedian in the remaining 8. Two of the subterminal chromosomes ( $2\mu$ ) are distinctly shorter than the rest ( $3-4\mu$ ).

**64. *Verbascum phoeniceum* L.  $n=16$ (PMC), Fig. 83. Cult.**

This plant will present one of the good examples concerning the relationship of bivalent arrangement to their secondary association (cf. No. 30). According to LAWRENCE (1930)<sup>2)</sup>, the basic number of *Verbascum* is 8. The present material then will be of a tetraploid nature.

**65. *Linaria balbata* Dieter  $n=6$ (PMC), Figs. 84 and 85. Cult.****66. *Linaria dalmatica* Mill.  $n=6$ (PMC), Figs. 86 and 87. Cult.**

In the above two species, the chromosomes of the meiotic complement are all alike and can not be distinguished from each other. Usually each bivalent appears to have only one chiasma.

The number of chromosomes in these two species is in agreement with that found in a number of *Linaria* (HEITZ, 1926, '27<sup>3)</sup>, TJEJBES, 1928<sup>4)</sup>).

**67. *Pentstemon frutescens* Lamb.  $2n=40$ (RT), Fig. 88. Mt. Tyôkai, Prov. Uzen.**

The chromosome number given here for this species is in agreement with that reported by SAKAI (1934)<sup>5)</sup>. There is a little variation in the size of chromosomes within the complement. The insertions were not distinctly shown, but several types of chromosomes, subterminal, submedian and median, seem to exist.

The basic number of *Pentstemon* is considered to be 8 (cf. GAISER, 1930<sup>1)</sup>), so then the present species will be of a pentaploid nature.

1) GAISER, L. O., *Genetica*, **8** (1926), 401-84, *ibid.*, **12** (1930), 161-260; *Bibliog. Gen.*, **6** (1930), 171-466 and *ibid.*, **10** (1933), 105-250.

2) LAWRENCE, W. J. C., *Genetics*, **12** (1930), 269-96.

3) HEITZ, E., *Zit. Bot.* **18** (1926), 625-81, *Planta* **7** (1927), 392-410 and *Abhandl. Gebiete Naturw. Hamburg*, **21** (1927), 45-57, pl. VIII.

4) TJEJBES, K., *Hereditas*, **10** (1928), 328-32.

5) SAKAI, K., *Jap. Journ. Gen.*, **9** (1934), 226-30.

**68. *Pedicularis apodochila* Maxim.  $2n=32$ (RT), Figs. 89 and 90.  
Mt. Gassan, Prov. Uzen.**

The somatic complement consists of 4 pairs of long and submedian chromosomes, 10 pairs of short and subterminal ones, and 2 pairs of short and apparently terminal.

The present material may possibly prove to be of a tetraploid nature, as the basic number of this genus may be 8 (*cf.* No. 69).

**69. *Pedicularis japonica* Miq.  $n=8$ (PMC), Figs. 92 and 92. Mt. Daisetū, Prov. Isikari.**

The meiotic chromosomes of the complement are rather large and variable in size to a certain extent. Owing to probable secondary association of one pair of bivalents at the meiotic metaphase, one may easily count the haploid number as 7 (Fig. 92); however 8 bivalents are clearly distinguishable when the secondary association is lacking (Fig. 91).

**70. *Plantago Mohnikei* Miq.  $2n=24+2ff.$ (RT), Figs. 93 and 94.  
Mt. Gassan and Tyōkai, Prov. Uzen.**

The somatic chromosomes of the complement are rather uniform in size. The insertions are median in 8 chromosomes and subterminal in the rest. Among the latter several, at least three, types are distinguishable by the relative position of the insertion. In addition to these 24 chromosomes, there are two very small chromosomes which are probably fragments. In the somatic complement of the material from one locality (Mt. Gassan) no satellited chromosomes exist (Fig. 93), while in the material from another locality (Mt. Tyōkai), one pair provided with a satellite was always identifiable (Fig. 94).

Since the basic number for most species of *Plantago* is considered as 6 (NEMEC 1910<sup>1</sup>), ISHIKAWA 1916<sup>2</sup>), EKSTRAND 1918<sup>3</sup>), SINOTO 1925<sup>4</sup>), HEITZ 1927<sup>5</sup>), TJEBBES 1928<sup>6</sup>) and McCULLAGH 1934<sup>7</sup>), the present material will be of a tetraploid nature, though it is not decided at present how these two fragments have originated and whether or not they are the constant

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- 1) NEMEC, B., Prob. Befr. u. zyt. Fragen. Berlin (1910), 1-532, pl. I-V.
  - 2) ISHIKAWA, M., Bot. Mag. (Tokyo), **30** (1916), 404-8.
  - 3) EKSTRAND, H., Svensk Bot. Tids., **12** (1918), 202-6.
  - 4) SINOTO, Y., Bot. Mag. (Tokyo), **39** (1925), 159-66.
  - 5) HEITZ, E., Abh. Geb. Naturw. Hamburg, **21** (1927), 45-57, pl. VII.
  - 6) TJEBBES, K., Hereditas, **10** (1928), 328-32.
  - 7) McCULLAGH, D., Genetica **16** (1934), 1-44.

characteristic of this species.

**71. Sambucus Buergeriana Bl. var. Miquelii Nakai n=19(PMC),**  
Fig. 95. In circa Sapporo, Prov. Isikari.

The 19 meiotic chromosomes are all generally large with a variation to a certain extent in size. Our finding is incompatible with the previously reported number,  $n=18$ , for the other species of *Sambucus* (cf. von BOENICKE 1921<sup>1)</sup>, WINGE 1917<sup>2)</sup> and KLEINMAN 1923<sup>3)</sup>, for *S. nigra*; LAGERBERG 1909<sup>4)</sup> for *S. racemosa*; VILMORIN & SIMONET 1927<sup>5)</sup> for *S. alseuoides*; SAX & KRIBS 1930<sup>6)</sup> for *S. canadensis*, *S. nigra* and *S. racemosa*).

**72. Lonicera sempervirens L. n=18 (PMC), Fig. 96. Cult.**

**73. Lonicera sp. n=36(PMC), Fig. 97. Cult.**

The meiotic chromosomes of the complement in these two species are very small. In Fig. 96 which represents a nucleus at late anaphase of the first meiotic division in polar view, the chromosomes are somewhat irregular in appearance.

According to SAX and KRIBS (1930)<sup>6)</sup>, 15 species of *Lonicera* have  $n=9$ , 4 species  $n=18$  and one species  $n=27$ . On the assumption that 9 is the basic number, the present two materials will be of a tetraploid and an octaploid nature respectively. From these results, it seems highly probable that the genus *Lonicera* consists of forms which constitute a series of multiples of 9 without exception.

**74. Adoxa Moschatellina L. n=28(PG), Fig. 98. Mt. Moiwa, Prov. Isikari.**

The chromosomes of the haploid complement are wide, more or less bent or curved, and vary in length to a certain extent. The insertions were not distinctly identifiable. LAGERBERG (1909)<sup>4)</sup> found  $n=18$  and  $2n=36$  in the same species.

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- 1) VON BOENICKE, L., Ber. Deu. Bot. Ges. **29** (1911), 59-65, pl. IV.
  - 2) WINGE, O., C. R. Trav. Labor. Carlsberg **13** (1917), 131-275, pl. I.
  - 3) KLEINMAN, A., Bot. Arch. **4** (1923), 113-47, pl. I-VI.
  - 4) LAGERBERG, T., K. Svensk. Vet. Akad. Hand. **44** (1909), 41-86, pl. I-III.
  - 5) DE VILMORIN, R., & M. SIMONET, C. R. Soc. Biol. Paris, **96** (1927); 116-8.
  - 6) SAX, K. & D. A. Kribs, Journ. Arnold Arb. **11** (1930), 147-153, pl. XXIV.

75. *Valeriana flaccidissima* Maxim.  $2n=16$ (RT), Fig. 99. Kamakura, Prov. Sagami.

The somatic complements seem to consist of the following several typed chromosomes, (i) 4 long and subterminal, (ii) 2 medium long and submedian, (iii) 4 medium long and terminal, (iv) 4 short and submedian and (v) 2 short, subterminal and satellited.

Since SENJANINOVA (1927)<sup>1)</sup> found that *Valeriana* constitutes a diploid series of 14–28–56, our finding will be interesting in presenting an exceptional case to this polyploid series.

76. *Campanula allariaefolia* Willd.  $n=48$ (PMC), Figs. 100 and 101. Cult.

The meiotic chromosomes of this plant are extremely uniform in their size and shape. No irregularities have been found in the meiotic divisions.

The genus *Campanula* contains forms of 8, 16, 17 and 51 chromosomes as the haploid set (cf. GAISER<sup>2)</sup>, 1930, 1933). The present material then is one member of the 8-series and of a hexaploid nature.

77. *Adenophora hakusanensis* Nakai  $n=17_{III}$ (PMC), Fig. 103 and 17(PG), Fig. 102. Mt. Gassan, Prov. Uzen.

78. *Adenophora remotiflora* Miq.  $n=18_{II}+1_I$ (PMC), Figs. 104 and 105. Mt. Zaô, Prov. Uzen.

79. *Adenophora Thunbergiana* forma *hirsuta* Kudô  $n=17_{II}+1_{III}$ (PMC), Fig. 106. Mt. Zaô, Prov. Uzen.

The three species of *Adenophora* dealt with here are especially interesting in the diversity of their chromosomal constitutions. They make a marked contrast to other species of *Adenophora* previously reported by MODILEWSKI (1934)<sup>3)</sup> who counted 17 haploid and 34 diploid chromosome numbers.

The present observations lead one to a conclusion that *A. hakusanensis* is an autotriploid form. Several assortments of trivalents, bivalents and univalents were met with at the first meiotic metaphase; the total chromosome number however comes to 51. The distribution of chromosomes to

1) SENJANINOVA, M., Zeitschr. Zellforsch. Mikrosk. Anat., 6 (1927), 675–9.

2) GAISER, L. O., Biol. Gen., (1930), 171–466, *ibid.*, 10 (1933), 120–250 and *Genetica*, 12 (1930), 162–260.

3) MODILEWSKI, I., Bull. Jard. Bot. Kyiv, 17 (1934), 3–10.

the poles at the first division is expected to range between 17 and 34. The pollen grain containing 17 chromosomes, as shown in Fig. 102, is then of rare occurrence.

In the other two species, *A. remotiflora* and *A. verticillata*, the diploid number is 37, but in chromosome assortment they differ from each other, the former being characterized by  $18_{II} + 1_I$  and the latter by  $17_{II} + 1_{III}$ . The distribution of chromosomes to the poles at the first division takes place in a fashion of either 18-1-18 or 18-0-19 in the former species (Fig. 105).

It will be noted here also that there is certain evidence of secondary association of bivalents at the first and second metaphase of meiosis in these materials (cf. Fig. 104), though the exact analysis of associated bivalents is not possible at present. Such chromosomal situations may be also suggested from some of MODILEWSKI's figures (cf. Figs. 16 and 17 in his paper).

A more critical study on the karyological analysis of the genus *Adenophora* is now in progress on more extended material.

**80. *Solidago japonica* Kit. var. *alpicola* Kitamura  $2n=18(RT)$ ,  
Fig. 107. Mt. Zaô, Prov. Uzen.**

The somatic chromosomes of the complement are nearly uniform in their length. The complement consists of 6 pairs of submedian chromosomes and 3 pairs of subterminal ones.

CARANO (1921)<sup>1)</sup> observed 9 haploid chromosomes in *Solidago canadensis* and 18 in *S. Riddellii*.

**81. *Erigeron glabratus* Hop. & Horns.<sup>2)</sup>  $n=18(PMC)$ , Fig. 108.  
Mt. Daisetū, Prov. Isikari.**

TAHARA (1915, '21)<sup>3)</sup> and HOLMGREN (1919)<sup>4)</sup> report that in many other species of *Erigeron* the haploid number is 9 and recently SAKAI (1934)<sup>5)</sup> gives also  $2n=18$  for this species. It will then be naturally inferred that the present material which is characterized by 18 bivalents is of a tetraploid nature. Owing to scarcity of good preparations, our

1) CARANO, E., Ann. di Bot., **16** (1921), 97-196, pl. IV-XII.

2) The present material is, according to Dr. KITAMURA of Kyoto Imperial University, referred to *Aster consanguineus* LEDEB.

3) TAHARA, M., Bot. Mag. (Tokyo), **29** (1915), 245-54, and *ibid.*, **43** (1921), 1-54, pl. I-IV.

4) HOLMGREN, J., K. Svensk Vet. Akad. Handl. **59** (1919), 1-72.

5) SAKAI, K., Jap. Journ. Gen., **9** (1934), 226-230.

observations do not go to give any exact information as to the morphology of chromosomes and their behavior at meiosis.

**82. *Artemisia sinanensis* Yabe**  $2n=18$  (RT), Fig. 109. Mt. Gassan, Prov. Uzen.

Of the 18 chromosomes of the complement, 8 have submedian insertions and the remaining 10 subterminal. Among the latter chromosomes, six have the short arms about  $1/3$  as long as the long arms and in the other four, the short arms are over half the length of the long arms.

According to WEINEDL-LIEBAU (1928)<sup>1)</sup> the haploid number is 9 in several species of *Artemisia* and CHIARUGI (1926)<sup>2)</sup> observed 27 diploid number in *A. nitida* which may be probably of a triploid nature.

**83. *Mallotopus japonicus* Fr. & Sav.**  $2n=18$  (RT), Fig. 112. Mt. Gassan, Prov. Uzen.

The somatic chromosomes of the complement vary in length, ranging from about  $3\mu$  to  $8\mu$ . The insertions are not clearly distinguished, but there seem to be 3 pairs of submedian or median chromosomes and the remaining 3 pairs of subterminal ones.

**84. *Senecio nemorensis* L.**  $n=20$  (PMC), Fig. 110;  $2n=40$  (RT), Fig. 111. Mt. Gassan, Prov. Uzen.

Within the complement, there are 12 pairs with distinctly marked median insertions. Consequently they are more or less V-shaped. The remainder have subterminal insertions, in which there are at least 4 satellited chromosomes. At the meiotic metaphase, a certain degree of secondary association of bivalents was noted.

OKABE (1931)<sup>3)</sup> gives  $n=20$  for the same species, in accordance with the present finding. The genus *Senecio* contains polyploid forms constituting a series of multiples of 5 (*cf.* AFZELIUS, 1924)<sup>4)</sup>. The present material is then of an octaploid nature.

**85. *Cirsium chokaiense* Kitamura**  $2n=34$  (RT), Fig. 113. Mt. Tyôkai, Prov. Uzen.

**86. *Cirsium ganjuense* Kitamura**  $2n=68$  (RT), Fig. 114. Mt. Iwate, Prov. Mutu.

1) WEINEDL-LIEBAU, F., Jahrb. wiss. Bot., **69** (1928), 636-86.

2) CHIARUGI, A., R. Acad. Del Lincei Atti., S. VI, **3** (1926), 281-4.

3) OKABE, S., Bot. Mag. (Tokyo), **45** (1931), 258-60.

4) AFZELIUS, K., Acta Horti Bergiani, **8** (1924), 123-319.

87. **Cirsium purpuratum Matsum.**  $2n=34$ (RT), Fig. 115. Mt. Zaô, Prov. Uzen.

88. **Cirsium ugoense Nakai (?)**  $2n=34$ (RT), Fig. 116. Mt. Gassan, Prov. Uzen.

The somatic chromosomes in these species of *Cirsium* are rather small and of exceedingly variable length, ranging from long ones with median insertions to very short ones in which the insertion regions are not clearly distinguishable.

AISHIMA (1934)<sup>1)</sup> dealing with 30 other species of this genus found a series of 17-34-51 haploid chromosomal groups. The present findings are in accordance with his observations.

89. **Sausurea brachycephala Franch.**  $2n=26$ (RT), Fig. 117. Mt. Tyôkai, Prov. Uzen.

90. **Sausurea sagitta Franch.**  $2n=26$ (RT), Fig. 118. Mt. Iwate, Prov. Mutu.

91. **Sausurea Riederi Herd. var. japonica Koidz.**  $2n=39$ (RT), Fig. 119. Mt. Tyôkai, Prov. Uzen.

The somatic chromosomes in these species are of nearly equal length. The insertions were not so conspicuously distinguishable as to permit one to identify the chromosome individuals. It is certain however that there are several types of chromosomes, median, submedian and subterminal, within each complement of these materials.

Taking the basic number of chromosomes as 13, the two species *S. alpicola* and *S. sagitta* are diploid, and the other species, *S. Riederi*, is triploid. These findings are not in accordance with the haploid number of 18 found by ISHIKAWA (1911)<sup>2)</sup> in *S. affinis*.

92. **Gerbera Anandria Schultz**  $2n=46$ (RT), Fig. 120. Makomanai, Prov. Isikari.

The somatic complements consist of chromosomes of nearly equal size. The insertions were not decidedly shown, but most of the chromosomes seem to be submedian or subterminal. One chromosome was found to be satellited.

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1) AISHIMA, T., Bot. Mag. (Tokyo), **48** (1934), 150-51.

2) ISHIKAWA, M., Bot. Mag. (Tokyo), **25** (1911), 339, and *ibid.*, **30** (1916), 404-48.

- 93. *Hieracium japonicum* Fr. & Sav.  $2n=14$ (RT), Fig. 121. Mt. Gassan, Prov. Uzen.**

The somatic complement appears to contain several types of chromosomes, median, submedian and subterminal. One chromosome (probably one pair) carries a satellite.

Several chromosome numbers have been hitherto known in the genus *Hieracium*, and the present material represents one of the smallest number of chromosomes, as in *H. venosum* (ROSENBERG, 1907)<sup>1)</sup>.

- 94. *Taraxacum hondoense* Nakai  $2n=24$  (RT), Fig. 122. Mt. Zaô, Prov. Uzen.**

The present material was obtained from a shaded place of the *Betula* zone (ca. 1500 s.m.s.) of Mt. Zaô, and is characterized by very vigorous habit of growth. It is considered to be triploid, for all the species of *Taraxacum* so far investigated have been known to have 8 chromosomes as the basic complement (MIYAJI, 1932<sup>2)</sup>, and GUSTAFSSON, cf. 1935<sup>3)</sup>).

The somatic complement of this plant seems to consist of 15 submedian and 9 subterminal chromosomes.

- 95. *Helodea densa* Casp.  $n=24(23+XY)$  (PMC), Fig. 123. Cult.**

In the meiotic complement, a wide range of variation in the size of chromosomes is observed. The largest chromosome attains  $2.5\mu$  in length, and the smallest one only  $0.5\mu$ . One pair of the 24 bivalents is clearly heteromorphic, and considered therefore to represent the sex-chromosomes of the XY type, as found by SANTOS (1924)<sup>4)</sup> in *Helodea* (= *Elodea*) *canadensis*.

- 96. *Glyceria pallida* Trin.  $2n=20$ (RT), Fig. 124. Mt. Daisetū, Prov. Isikari.**

The chromosomes of the complement vary in length, ranging from ca.  $3\mu$  to  $1.5\mu$ . The insertions were not clearly differentiated owing to rather poor fixation.

- 97. *Hakonechloa macra* Makino  $2n=50$ (RT), Fig. 125. Cult.**

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1) ROSENBERG, O., Bot. Tids., **82** (1907), 143-70, pl. I-II; Svensk Bot. Tids., **1** (1907), 398-410, pl. VIII.

2) MIYAJI, T., Bot. Mag. (Tokyo), **46** (1932), 406-8.

3) GUSTAFSSON, A., Hereditas, **21** (1935), 1-112.

4) SANTOS, J. K., Bot. Gaz., **75** (1924), 42-59, pl. III.

98. **Hakonechloa macra var. aureola Makino**  $n=50$ (RT), Fig. 126. Cult.

The somatic complement of these plants consists of 50 small chromosomes. They appear to vary in length to a certain extent.

99. **Philodendron Andreanum Dev.**  $2n=34$ (RT), Fig. 127. Cult.

The somatic complement consists of 12 pairs of short chromosomes which are fairly uniform and generally have submedian insertion, 4 pairs of long ones, the insertions of which are usually subterminal, and one pair which is characterized by a secondary constriction, one member of which is provided with a satellite.

100. **Alocasia macrorrhiza Schott**  $2n=26$ (RT), Fig. 128. Cult.

The chromosomes of the complement show considerable variation in length and have clear constrictions, so that it is easy to distinguish their individualities. Four pairs of the 26 chromosomes are subterminally inserted; one pair of them has a spherical short arm, and the remaining 3 pairs possess rod arms. In addition to these, 6 pairs have the insertions submedian, and 3 pairs median.

101. **Belbergia Liboniana D'jonghe**  $n=54$ (PMC), Fig. 129. Cult.

102. **Belbergia sp.**  $n=54$ (PMC), Fig. 131. Cult.

The meiotic chromosomes in these species show little morphological individuality, and are so widely separated at the metaphase that it was easy to count the exact number of 27 and 54 bivalents respectively.

LINDSCHAU (1933)<sup>1)</sup> reports also the haploid 27 and the diploid 54 and 72 chromosomes in other species of *Belbergia*.

103. **Cryptanthus acaulis Beer**  $n=17$ (PMC), Fig. 132. Cult.

The meiotic chromosomes of the complement are strikingly uniform in size and configuration. LINDSCHAU (1933)<sup>1)</sup> found 36 chromosomes in the somatic complement of the same species, which is not in accordance with the present finding.

104. **Pitcairnia muscosa Mast.**  $2n=50$ (RT), Fig. 131. Cult.

The chromosomes of the somatic complement are very small, ca.  $0.5\mu$

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1) LINDSCHAU, M., *Planta*, **20** (1933), 506-30.

long at the most and strikingly uniform in their shape. The chromosomes of this plant may be taken as representative of the smallest chromosome type hitherto known in higher plants.

In another species of *Pitcairnia*, TAYLOR (1925)<sup>1)</sup> found  $n=25$  and also in 6 species, LINDSCHAU (1933)<sup>2)</sup> found  $2n=50$ . These results are in accordance with the present finding.

**105. *Tradescantia amplexicaulis*<sup>3)</sup>  $n=8$ (PG), Fig. 134; (PMC), Fig. 135. Cult.**

Of the 8 chromosomes of the haploid complement, 7 are fairly equal in size and have subterminal insertions; the other 1 is much longer and has a submedian insertion. No satellited chromosomes were found. The meiotic divisions take place in the normal fashion. The bivalents at the first metaphase usually seem to have from 1 to 3 chiasmata.

The present material is of special interest in that it may present a new basic number for *Tradescantiae*, since several previous workers have reported  $n=6$  as the basic number (cf. GAISER, 1930<sup>4)</sup>, and ANDERSON & DIEHL, 1932<sup>5)</sup>). DARLINGTON (1929, '32)<sup>6)</sup> interpreted the existence of euploid and aneuploid forms in this section on the assumption of either the reduplication of the complement as the whole or the breaking up of a whole or part of it. In the present case, the 8 bivalents are normally formed, showing no sign of such complexities as his interpretation demands.

**106. *Cyanoptis somaliensis* Clarke  $2n=26$ (RT), Fig. 133. Cult.**

The chromosomes of the somatic complement are distinctly smaller than those in other species of *Tradescantiae* hitherto investigated. Six chromosomes have the insertions submedian and the other 20 subterminal, one of the latter bearing a seta.

DARLINGTON (1929, '32)<sup>6)</sup> gives a diploid number of 28 for this species. Probably the present material may therefore be of a karyotype different from the one treated by him.

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- 1) TAYLOR, R., Amer. Journ. Bot. **12** (1925), 238-68.
  - 2) LINDSCHAU, M., Planta, **20** (1933), 506-30.
  - 3) The author name of this species was not able to trace.
  - 4) GAISER, L. O., Bibl. Gen., **6** (1930), 171-466.
  - 5) ANDERSON, E. & D. G. DIEHL, Journ. Arnold Arb., **13** (1932), 213-31.
  - 6) DARLINGTON, C. D., Journ. Gen., **21**(1929), 207-86; *Recent Advances in Cytology* (1932), London.

**107. *Spironema fragrans* Lindl.  $n=6$ (PMC), Fig. 126;  $2n=12$  (RT), Figs. 137 and 138. Cult.**

The somatic chromosomes of the complement can be distinguished into five types as DARLINGTON (1929)<sup>1)</sup> and RICHARDSON (1934)<sup>2)</sup> have done. The present finding differs from theirs in that the pair corresponding to their third class lacks the secondary constriction. It is noteworthy also that the satellite of the chromosomes corresponding to DARLINGTON's fifth class varies considerably in size in different individuals. (Compare Fig. 137 with Fig. 138).

**108. *Tofieldia japonica* Miq.  $n=30$ (PMC), Fig. 139. Mt. Zaô, Prov. Uzen;  $2n=60$ (RT), Fig. 140. Mt. Gassan, Prov. Uzen.**

The chromosomes in the complement are extremely small and vary a little in size. In the majority of them the insertions are submedian or subterminal and at least 8 chromosomes appear to carry satellites, though it was sometimes very hard to distinguish satellites from short arms. The present species may be of a tetraploid nature, as contrasted with other species of *Tofieldia* (cf. No. 109). This is most probably related to the more vigorous habit of growth in this plant than in others.

**109. *Tofieldia nutans* Willd.  $2n=30$ (RT), Fig. 141. Mt. Iwate, Prov. Mutu.**

The chromosomes of the complement are very small. The constrictions were not clearly differentiated, as the fixation had caused some swelling of chromosomes. MILLER (1930)<sup>3)</sup> gives  $2n=28$  in *T. calyculata* and  $n=15$  in *T. palustris*.

**110. *Veratrum longibracteatum* Takeda  $n=8$ (PMC), Fig. 142. Mt. Gassan, Prov. Uzen.**

**111. *Veratrum Maximowiczii* Baker  $n=8$ (PMC), Fig. 143 Mt. Zaô, Prov. Uzen.**

The haploid complement consists of 8 rather large chromosomes in those two species, although those shown in these figures are exceedingly swollen due to the effects of long time of acetocarmine treatment and are not directly comparable with those in *V. oxysepatum* (No. 112) which were properly fixed.

1) DARLINGTON, C. D., *Journ. Gen.* **21** (1929); 207-85.

2) RICHARDSON, M., *Cytologia*, **5** (1934), 337-54.

3) MILLER, E. W., *Proc. Univ. Durham Philosoph. Soc.*, **8** (1930), 267-71.

**112. *Veratrum oxysepatum* Turcz.  $n=16$ (PMC), Figs. 114 and 145.  
In circa Sapporo, Prov. Isikari.**

The chromosomes of the meiotic complement vary slightly in size, though one pair is distinctly smaller than the others. It was noted that one pair of medium size tends to divide precociously at the first metaphase, resulting in the frequent occurrence of two univalents and 15 bivalents (Fig. 144). The secondary association of some bivalents was also very often met with at the first and second metaphase (Fig. 145). The present material may be reasonably considered as of an allotetraploid nature.

For *Veratrum album* MILLER (1930)<sup>1)</sup> counts about 16 somatic chromosomes. The present material is sometimes included by taxonomists under *V. album* as a variety, but the karyological situation of the former is quite different from that of the latter.

**113. *Veratrum stamineum* Maxim.  $n=18$ (PMC), Fig. 149;  $2n=32$ ,  $32+2ff.$ (RT), Figs. 146 and 147; Mt. Zaô, Prov. Uzen.**

Usually the somatic complement consists of 32 chromosomes (Fig. 147); in a few cases however two fragments are visible in addition to the normal complement (Fig. 146). Within the complement, these are 26 median chromosomes both long and short in length and 8 subterminal ones of medium length. In certain epidermal cells of root-tips of plants of  $32+2ff.$ , a tetraploid condition of nuclei, i.e.,  $64+4ff.$ , was observed (Fig. 148).

**114. *Tricyrtis latifolia* Maxim.  $2n=26$ (RT), Fig. 150. Mt. Zaô, Prov. Uzen.**

In root-tip cells, 26 chromosomes of various sizes are recognized. Two pairs of them are markedly long and 1 pair strikingly short. The insertions are subterminal in most of the chromosomes, except four of medium size which are nearly median. One pair of the largest chromosomes seems to be characterized by a secondary constriction on the distal part of the long arm.

MATSUURA (1935)<sup>2)</sup> found that the haploid number of the same material is 13 and there is secondary association between 2 bivalents of similar size

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1) MILLER, E. W., Proc. Univ. Durham philosoph. Soc., 8 (1930), 267-71

2) MATSUURA, H., Jour. Fac. Sci. Hokkaido Imperial University, S. V, 3 (1935), 251-260.

at the first meiotic metaphase. In 8 other species and 6 varieties of *Tricyrtis*, the same counts have been given by NAWA (1928)<sup>1)</sup>, MILLER (1930)<sup>2)</sup> and SINOTO & KIKKAWA (1931)<sup>3)</sup>. MILLER described satellited chromosomes, but in the present material no satellite was visible.

**115. *Anthericum ciliatum* Spring  $n=7$ (PG), Fig. 151. Cult.**

The seven chromosomes of the haploid complement are easily distinguishable individually according to the size of chromosomes, relative position of insertions, and the presence or absence of the satellite. Five of them are long and the remaining two are very short being only 1/3 as long as the long chromosomes. Among the long chromosomes, one has a satellite, and another a secondary constriction on the distal part of the long arm.

Previously the reduced number of chromosomes was reported to be 16 in *Anthericum ramosum* (ELVERS, 1932)<sup>4)</sup> and in *A. roseum* (STENAR, 1928)<sup>5)</sup>, and 32 in *A. liliago* (ELVERS)<sup>4)</sup>. The present material is therefore especially interesting as contrasted with these species.

**116. *Chlorophytum elatum* R. Br.  $2n=28$ (RT), Fig. 153. Cult.**

**117. *Chlorophytum elatum* var. *variegatum* Hort.  $n=14$ (PMC), Fig. 152. Cult.**

The somatic complement consists of 4 submedian chromosomes of medium size and 24 subterminal ones which vary to a certain extent in length and also in the relative position of the insertions.

The meiotic divisions take place in the normal fashion.

For another species, *C. Sternbergianum*, STRASBURGER (1881)<sup>6)</sup> gave counts of  $n=12$  and SUSSENGTH (1920)<sup>6)</sup>  $n=6$ .

**118. *Hosta japonica* Aschers. & Graebn.  $n=30$ (PMC), Fig. 155. Cult.**

**119. *Hosta lancifolia* Engler  $2n=60$ (RT), Fig. 156. Mt. Tyôkai, Prov. Uzen.**

**120. *Hosta* sp.  $2n=60$ (RT), Fig. 156. Mt. Tyôkai, Prov. Uzen.**

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- 1) NAWA, N., Bot. Mag. (Tokyo), **42** (1928), 33-36, pl. VII.
  - 2) MILLER, E. W., Proc. Univ. Durham Philosoph. Soc., **8** (1930), 267-71.
  - 3) SINOTO, Y. & R. KIKKAWA, Jap. Journ. Gen., **7** (1931), 194-98.
  - 4) ELVERS, L., Svensk Bot. Tids., **26** (1932), 13-24.
  - 5) STENAR, H., Bot. Not. Lund, **5-6** (1928), 357-78.
  - 6) Ex GAISER, L. O., Bibl. Gen., **6** (1930), 171-466.

The complement of these species consists of 6 pairs of distinctly large chromosomes and 24 pairs of small ones. The large chromosomes are extremely subterminal inserted, so that the short arm appears in certain members of them as a minute body. In the small chromosomes, the insertions vary in their relative position. In an undetermined species obtained from Mt. Tyōkai there is one pair of satellited chromosomes.

These findings confirm the results obtained by AKEMINE (1935)<sup>1)</sup> of our laboratory.

**121. *Hemerocallis Dumortierii* Morr.  $n=11$ (PMC), Fig.157. Cult.**

The chromosomes all pair to form 11 bivalents at the first meiotic metaphase and no irregularities were noted during the divisions.

The chromosome number of this species agrees with that reported by several authors (such as TAKENAKA 1929<sup>2)</sup>, SIENICKA 1929<sup>3)</sup>, STOUT 1932<sup>4)</sup> and DARK 1932<sup>5)</sup>) in several other species of *Hemerocallis*.

**122. *Kniphofia pulchella*  $2n=12$ (RT), Fig. 158. Cult.**

Within the somatic complement, three chromosomal types are distinguishable, (i) median (about  $10\mu$  long), (ii) submedian (about  $9\mu$  long) and (iii) subterminal (about  $7\mu$  long). The complement consists of  $2(i) + 4(ii) + 6(iii)$ .

The reduced number was found to be usually 6 in the species hitherto studied in this genus (VILMORIN & SIMONET 1927<sup>6)</sup>, BELLING 1927<sup>7)</sup>, FERNANDES 1931<sup>8)</sup>, DARLINGTON 1932<sup>9)</sup>, WEBBER 1932<sup>10)</sup>, MOFFETT 1932<sup>11)</sup>), agreeing with the diploid number here reported in the present species.

**123. *Gasteria* sp.  $n=7$ (PG), Fig. 162. Cult.**

**124. *Aloe* sp.  $n=7$ (PMC), Fig. 159. Cult.**

**125. *Aloe* sp.  $n=7$ (PMC), Figs. 160 and 151. Cult.**

The chromosome complement is quite similar in these genera. There

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- 1) AKEMINE, T., Journ. Fac. Sci., Hokkaido Imp. Univ., S. V, 5 (1935), 25-32.
  - 2) TAKENAKA, Y., Cytologia, 1 (1929), 76-84.
  - 3) SIENICKA, A., Acta Soc. Bot. Polon., 6 (1929), 296-334, Pl. XVIII-XX.
  - 4) STOUT, A. B., Cytologia, 3 (1932), 250-9.
  - 5) DARK, S. O. S., New Phytol., 31 (1932), 310-20.
  - 6) DE VILMORIN, R. & M. SIMONET, C. R., Acad. Sci. Paris, 184 (1927), 164-6.
  - 7) BELLING, C., Univ. Calif. Publ. Bot., 14 (1928), 335-43.
  - 8) FERNANDES, A., Bol. Soc. Brot., s 2, 7 (1931), 1-110, pl. I-XV.
  - 9) DARLINGTON, C. D., Cytologia, 4 (1933), 229-40.
  - 10) WEBBER, J. M., Amer. Jour. Bot., 19 (1932), 411-12, pl. XXV.
  - 11) MOFFETT, A. A., Journ. Gen., 25 (1932), 315-33, pl. X.

are 4 very long chromosomes and three very short ones in the haploid set. The insertions are subterminal in all these chromosomes. In a pollen grain of *Aloe*, one extra long chromosome was found to be duplicated (Fig. 161). Occasional occurrence of such addition or reduction of certain chromosomes was described by MARSHAK (1934)<sup>1)</sup> in *Aloe*, *Gasteria*, *Haworthia* and *Aprica*.

**126. *Haworthia* sp.  $n=7$ (PMC, PG), Figs. 183 and 164. Cult.**

The chromosomes of this species are quite similar to those of *Aloe* and *Gasteria* in their morphology and behavior. Four long and three short chromosomes are easily distinguishable in the meiotic (Fig. 163) as well the somatic complement (Fig. 164). All the species of *Haworthia* examined hitherto by TAYLOR (1925)<sup>2)</sup> and FERGUSON (1926)<sup>3)</sup> have been found to have 7 haploid chromosomes.

**127. *Agapanthus excelsus*<sup>4)</sup>  $n=15$ (PMC), Fig. 165. Cult.**

**128. *Agapanthus umbellatus* L'Hérit.  $n=15$ (PMC), Fig. 166. Cult.**

The chromosome conditions are essentially similar in these species. The meiotic complement consists of 15 large bivalents in both the species. *A. umbellatus* has been karyologically treated by BELLING (1928)<sup>5)</sup> and DARLINGTON (1933)<sup>6)</sup>.

**129. *Gagea lutea* Ker-Gawl.  $n=36$ (PG), Fig. 167. In circa Sapporo, Prov. Isikari.**

The reduced number of chromosomes of this plant is 36, as previously shown by SAKAMURA & STOW (1926)<sup>7)</sup>. The complement consists apparently of several types of chromosomes in respect to their size and the relative position of constrictions. Two chromosomes are satellited.

**130. *Allium Schoenoprasum*. L. var. *typicum* Regel  $n=8$ (PG), Fig. 168; (PMC), Fig. 169. Mt. Teine, Prov. Isikari.**

The haploid complement consists of 5 median chromosomes of various

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1) MARSHAK, A., Amer. Journ. Bot., **21** (1934), 592-6, pl. I.

2) TAYLOR, W. R., Amer. Journ. Bot., **12** (1925), 219-23.

3) FERGUSON, N., Roy. Soc. London Phil. Trans. B., **215** (1926), 225-53, pl. XVIII-XIX.

4) The author name of this species could not be traced.

5) BELLING, J., U. C. Pub. Bot., **14** (1928), 335-43.

6) DARLINGTON, C. D., Cytologia, **4** (1933), 229-40.

7) SAKAMURA, T. & I. STOW, Jap. Journ. Bot., **3** (1926), 111-38, pl. III.

sizes, 2 submedian of apparently equal size, and 1 subterminal. The last one is satellited, and is invariably connected with the nucleolus at prophase by its achromatic region (MATSUURA 1935)<sup>1)</sup>. The meiotic divisions take place normally.

The diploid number, 16, was counted by KATAYAMA (1928)<sup>2)</sup> and SAKAI (1934)<sup>3)</sup> in the same species, but they did not observe any satellited chromosome.

**131. *Allium Victorialis* L. subsp. *platyphyllum* Hultén  $n=16$**   
(PMC), Fig. 170. Mt. Moiwa, Prov. Isikari.

All the bivalents at MI are characterized by the so-called localized chiasmata, taking the cruciform type, as described in *A. Farreri* and *A. fistulosum* by LEVAN (1933, '35)<sup>4)</sup>.

No irregularities of the meiotic divisions were noticed.

For *A. Victorialis*, LEVAN (1935) gives the reduced number as 8. The present material then will be of an allotetraploid nature, as previously shown by HIRATA & AKIYAMA (1927)<sup>5)</sup> and by SAKAI (1934)<sup>6)</sup>.

**132. *Nothoscordum fragrans* Kunth  $n=8_{IV}$  (PMC), Fig. 171. Cult.**

The present material is characterized by auto-tetraploidy with the basic number of 8. Usually most of the chromosomes form tetravalents, and in the extreme case 8 tetravalents arrange themselves at the heterotypic spindle (Fig. 171).

It was found from the first vegetative division of the pollen grain that the basic complement consists of 7 chromosomes with median insertions and 1 with a subterminal one and a small proximal satellite. Irregularities in the distribution of the chromosomes at the meiotic divisions will cause to originate pollen grains of several different chromosomal constitutions. Of 6 pollen grains examined, 3 were found having 15 chromosomes, 2 having 16 and 1 having 17. Fig. 172 represents 15 chromosomes in a pollen grain of which 13 are median and 2 are satellited.

The idiogram of the present species closely resembles that of *N. bivalve*

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- 1) MATSUURA, H., Bot. & Zool., **3** (1935), 1589-94.
  - 2) KATAYAMA, Y., Journ. Sci. Agr. Soc. Japan, **303** (1928), 52-4.
  - 3) SAKAI, K., Jap. Journ. Gen., **9** (1934), 226-30.
  - 4) LEVAN, A., Svensk Bot. Tids., **27** (1933), 211-232, and Hereditas, **20** (1935), 289-330.
  - 5) HIRATA, K. & S. AKIYAMA, Bot. Mag. (Tokyo), **41** (1927), 597-600.
  - 6) SAKAI, K., Jap. Journ. Gen., **9** (1934), 226-30.

(BEAL, 1932)<sup>1)</sup> which has 9 haploid chromosomes, excepting that the latter has 2 terminally inserted chromosomes instead of the subterminal ones in the former.

The chromosome numbers found in the present species and its related one, *N. bivalve*, are listed as follows:

<i>N. fragrans</i>	9 <sub>II</sub>	STENAR (1932) <sup>2)</sup> , LEVAN (1935) <sup>3)</sup> .
	8 <sub>II</sub>	KOERPERICH (1930) <sup>4)</sup> .
	8 <sub>IV</sub>	The present writers.
<i>N. bivalve</i>	9 <sub>II</sub>	BEAL (1932) <sup>1)</sup> , ANDERSON (1931) <sup>5)</sup> .
	8 <sub>IV</sub> *	„ „

\* In this race BEAL actually found 7<sub>IV</sub>+2<sub>II</sub> in a PMC.

From these results it may be inferred with certainty that both the species contain 8- and 9-chromosomal races in common.

**133. *Lilium medeoloides* A. Gray n=12 (PMC), Fig. 174, Mt. Teine, Prov. Isikari; n=12+1f (PMC), Fig. 175, Mt. Sapporo-dake, Prov. Isikari; 2n=24 (RT), Fig. 173, Is. Sado, Prov. Etigo.**

The somatic complement consists of two pairs of V-shaped chromosomes having submedian insertions, three pairs of J-shaped ones, their short arms being about one fifth the long arms, three pairs of extremely subterminal ones and three pairs of subterminal ones provided with secondary constrictions at nearly the middle point of the long arm. The idiogram is similar to that given by SATÔ (1932)<sup>6)</sup> for the same species, though a certain difference is noticed in his figure as to the relative position of the secondary constriction in these three pairs of chromosomes.

Plants of several different localities, such as Is. Sado, Mt. Tyôkai and Mt. Iwate, in Honshu and Mt. Sapporo-dake and Mt. Teine, in Yezo, have been karyologically examined by the writers, with an aim to find out karyotypes, if any, within this species. No marked differences were observed between these materials as to the chromosome organization, except a case noted in an individual collected at Mt. Sapporo-dake, in which all the PMC were characterized by an extra fragmental chromosome, much smaller than

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- 1) BEAL, J. M., Bot. Gaz. **93** (1932), 105-6 and 278-95, pl. II-III.
  - 2) STENAR, H., Svensk Bot. Tids., **26** (1932), 25-44, pl. I-II.
  - 3) LEVAN, A., Hereditas, **20** (1935), 289-330.
  - 4) KOERPERICH, G., La Cellule, **33** (1930), 309-98.
  - 5) ANDERSON, E., Ann. Miss. Bot. Gard., **18** (1931), 465-8.
  - 6) SATÔ, M., Bot. Mag. (Tokyo), **46** (1932), 68-88.

the members of the normal complement (Fig. 175).

**134. *Cardiocrinum Glehni* Makino  $n=12$  (PMC), Fig. 176. Mt. Moiwa, Prov. Isikari.**

The 12 bivalents of the complement are all large and each is apparently conditioned by many chiasmata. The same haploid count was given in *C. cordatum* by TAKAMINE (1916)<sup>1)</sup> and the diploid number, 24, by MORINAGA & FUKUSHIMA (1931)<sup>2)</sup>.

**135. *Eucomis bicolor* Baker  $2n=30$  (RT), Fig. 177. Cult.**

The somatic complement consists of 8 very long chromosomes (ca. 4–7  $\mu$ ) with subterminal insertions and 22 very short ones (ca. 1–3  $\mu$ ) with either submedian or subterminal insertions. One pair of subterminal short chromosomes is provided with satellites.

KOERPERICH (1930)<sup>3)</sup> gives the same diploid number for this species.

**136. *Eucomis punctatum* L. Her.  $2n=60$  (RT), Fig. 178. Cult.**

The chromosome complement of this plant very much resembles that of *E. bicolor* (No. 135), but it differs from the latter in having 60 chromosomes instead of 30 and in lacking the satellited chromosomes.

**137. *Ornithogalum umbellatum* L.  $2n=54$  (RT), Fig. 179. Cult.**

The chromosome complement of this species is generally similar to that of *Hosta* and *Eucomis*. It consists of 16 very long chromosomes with spherical short arms bounded by the subterminal insertions, 2 of them having secondary constrictions, 8 short chromosomes and 30 distinctly shorter ones. This species seems to contain other chromosomal forms, for the chromosome number has already been reported to be  $n=24-28$  (HEITZ 1926)<sup>4)</sup> and  $2n=27$  or 45 (SPRUMONT, 1928)<sup>5)</sup>.

**138. *Drimiopsis botrycoides* Baker  $n=40$  (PMC), Fig. 180. Cult.**

Of the 40 bivalents of the complement, 10 are very long, arranged at the periphery of the plate and apparently conditioned by 3 or more chiasmata in each, 6 are medium sized and have usually 2 chiasmata and the

1) TAKAMINE, N., Bot. Mag. (Tokyo), **30** (1916), 293–303.

2) MORINAGA, T. & E. FUKUSHIMA, Bot. Mag. (Tokyo), **45** (1931), 140–45.

3) KOERPERICH, G., La Cellule, **39** (1930), 309–98, pl. I–III.

4) HEITZ, E., Zeitsch. Bot., **18** (1926), 625–81, pl. V.

5) SPRUMONT, G., La Cellule, **38** (1928), 269–92, pl. I–II.

remainder, 24, are distinctly small-sized and characterized by a terminal chiasma.

According to BARANOV (1926)<sup>1)</sup>, another species, *D. maculata*, has 64 diploid chromosomes, in which 4 large satellites seem to be associated with 4 long chromosomes and 12 to 16 small satellites with short ones.

**139. *Hyacinthus orientalis* L.  $n=8$ (PG), Fig. 181. Cult.**

It has been repeatedly shown by several earlier workers (*cf.* GAISER, 1930<sup>2)</sup>) that the present species has 8 basic chromosomes. According to DARLINGTON (1929)<sup>3)</sup> and STONE & MATHER (1932)<sup>4)</sup>, the diploid complement is composed of three types of chromosomes, namely, four long ( $21\mu$  long), two medium long ( $9\mu$  long) and two short ( $5\mu$  long) pairs. It has also been shown that the long chromosomes have median insertions, one pair of which is characterized by secondary constrictions, and the remainder by subterminal insertions. These observations are entirely in accordance with the situation indicated by Fig. 181.

**140. *Muscari botryoides* Mill.  $n=24$ (PG), Fig. 182. Cult.**

In the haploid complement, there are 4 very long chromosomes with subterminal insertions, 8 of medium size, 3 of which have the insertions median and the remaining 5 subterminal, and 12 short subterminal chromosomes of nearly equal size.

For the same species,  $2n=36$  was previously reported by MÜLLER (1912)<sup>5)</sup> and also by DELAUNEY (1915 '27)<sup>6)</sup>. The present material is therefore of a karyotype quite different from those treated by these authors.

**141. *Yucca aloifolia* L.  $2n=60$ (RT), Fig. 183. Cult.**

**142. *Yucca Wrightii*<sup>7)</sup>  $2n=60$ (RT), Fig. 184. Cult.**

As well known, the chromosome complement of *Yucca* is composed of two sharply delimited groups of chromosomes, very large ones and very small ones. In the present materials, these two chromosome types are also

1) BARANOV, P., Zeitschr. Zellforsch. Mikrosk. Anat., 3 (1926), 131-48.

2) GAISER, L. O., Bibl. Gen., 6 (1930), 171-466.

3) DARLINGTON, C. D., Journ. Gen. 21 (1929), 207-86 and Recent. Ad., Cyt., (1932), 1-559.

4) STONE, L. H. A. & K. MATHER, Cytologia, 4 (1932), 16-25.

5) MÜLLER, C., Arch. Zellforsch. 8 (1912), 1-51, pl. I-II.

6) DELAUNEY, L. N., Mem. Soc. Natur. Kiew. 25 (1915), 33-62 and Zeitschr. Zellforsch. Mikr. Anat., 4 (1927), 338-64.

7) The author name of this species has not been able to trace.

clearly distinguishable, the somatic complement consisting of 10 very long chromosomes (ca.  $3-3.2\mu$  long) with subterminal insertions and 50 very short ones (ca.  $0.3-1\mu$  long) with either subterminal or submedian insertions. A similar chromosomal organization is a characteristic of *Hosta* and *Eucomis*, but the size of the chromosomes is much smaller in *Yucca* than in them.

So far as the reliable works indicate, the haploid number of *Yucca* is 30 (MORINAGA *et alii*, 1929<sup>1)</sup>; O'MARA, 1931<sup>2)</sup>; MCKELVEY & SAX, 1933<sup>3)</sup>) and the diploid number 60 (WATKINS, 1935)<sup>4)</sup>. WATKINS observed marked somatic pairing of chromosomes in *Y. rupicola*. Such a tendency of similar chromosomes lying side by side at the somatic plate may be recognized also in our figures.

**143. *Sansevieria zeylanica* Willd.  $n=20$ (PMC), Fig. 185. Cult.**

Most of the bivalents are rod-shaped. The meiotic divisions are normal. HEITZ (1926)<sup>5)</sup> gives  $2n=102-104$  for *S. cylindrica*.

**144. *Sansevieria zeylanica* var. *variegata* Hort.  $2n=42$ (RT), Fig. 186. Cult.**

The somatic chromosomes are very small and of different size, ranging from ca.  $2\mu$  to ca.  $0.3\mu$ . The constrictions are indistinct, but in the largest pair, they seem to be subterminal.

**145. *Cordyline australis* Hook.  $n=60$ (PMC), Figs. 187 and 188. Cult.**

The present material has a higher chromosome number than any hitherto reported in *Liliaceae*. The first meiotic metaphase is characterized by the usual occurrence of a few polyvalents in addition to a number of bivalents. The bivalents are spherical in shape, rather uniform in size and configuration, and easily distinguishable from the polyvalents which are ring-shaped and composed of 4-8 chromosomes so far as observed. Of 7 PMC, 1 was found to have 60 bivalents, 4 to be of  $57_{II}+1_{VI}$  (Fig. 187) and 2 to be of  $52_{II}+1_{VIII}+2_{IV}$  (Fig. 188). Thus the present material seems

1) MORINAGA, T., E. FUKUSHIMA, T. KANO, Y. MARUYAMA and Y. YAMASAKI, Bot. Mag. (Tokyo), **45** (1929), 589-94.

2) O'MARA, J., Cytologia, **3** (1931), 66-76.

3) MCKELVEY, S. D. & K. SAX, Journ. Arnold Arb., **14** (1933), 76-81, pl. LV.

4) WATKINS, G. M., Bull. Torrey Bot. Club, **62** (1935), 133.

5) HEITZ, E., Zeit. Bot. **18** (1926), 625-81.

to be of a high polyploid nature.

**146. *Clintonia udensis* Trautv. & Mey.  $n=14$ (PG), Fig. 195. Mt. Sapporo-dake, Prov. Isikari.**

The length of chromosomes at the division of pollen grains varies from ca.  $13\mu$  to ca.  $7.5\mu$ . Of the 14 haploid chromosomes, 2 are the largest and median-inserted, 9 submedian or nearly subterminal, and 3 exceedingly subterminal. One of the last is furnished with a satellite.

In another species, *C. borealis*, SMITH (1911)<sup>1)</sup> gives counts of ca. 12 in meiosis of EMC and ca. 20 in root-tip cells.

**147. *Smilacina japonica* A. Gray var. *mandshurica* Maxim.  $n=18$  (PMC), Fig. 189. In circa Sapporo, Prov. Isikari.**

The present material is essentially the same as *S. japonica* treated by TAHARA (1933)<sup>2)</sup> in the chromosome organization. Of the 18 bivalents, 8 are distinctly larger than the rest.

**148. *Maianthemum dilatatum* Vels. & Macb.  $n=16$ (PMC), Fig. 196. In circa Sapporo, Prov. Isikari.**

Of the 16 bivalents, 4 are distinctly larger than the rest. The meiotic divisions are normal.

For the same species, LAWSON (1913)<sup>3)</sup> reports the haploid number to be 14 which does not agree with the present finding.

**149. *Disporum sessile* D. Don var. *macrophyllum* Koidz.  $n=8$  (PG), Fig. 197. In circa Sapporo, Prov. Isikari.**

The idiogram of the present material is essentially the same as that described by HASEGAWA (1932)<sup>4)</sup> for the diploid and the triploid races of *D. sessile*. The 8 chromosomes of the haploid complement are easily distinguishable individually.

**150. *Streptopus amplexifolius* DC.  $n=16$ (PG), Fig. 190, (PMC), Figs. 191 and 192. Mt. Moiwa, Prov. Isikari.**

The chromosomes in pollen grains are fairly large, but vary in length,

1) SMITH, R. W., Bot. Gaz., 25 (1911), 324-7, pl. XX.

2) TAHARA, M., Sci. Rep., Tohoku Imp. Univ. s 4, 8 (1933), 33-7.

3) LAWSON, A. A., Trans. Roy. Soc. Edinburgh, 48 (1913), 601-27.

4) HASEGAWA, N., Cytologia, 3 (1932), 350-68.

ranging from ca.  $5.5\mu$  to ca.  $2.2\mu$ . Eight chromosomes have median and the others subterminal insertions. No satellited chromosome was found.

The meiotic divisions are normal. At MI two bivalents are usually so closely associated together that it is hard to determine whether they form a tetravalent or are merely due to secondary association.

**151. *Streptopus japonicus* Ohwi.  $n=8+2ff$ (PG), Fig. 193. Mt. Hakkôda, Prov. Mutu.**

As in the preceding, the chromosomes in the pollen grain show a pronounced variation in size, so that the smallest chromosomes are only a quarter of the length of the largest. The insertions are in 3 chromosomes submedian, in 1 extremely subterminal, in 4 moderately subterminal and in the smallest two apparently absent. The last ones may be fragments. One subterminal chromosome is satellited.

In this connection it is worthy of note that *S. streptoides* Koidz., a species so related with *S. japonicus*, that it is sometimes considered as a variety of the latter, seems to have a different chromosomal organization. Though the observations on this plant are only preliminary at the present, 37 chromosomes were found in a pollen grain of a plant from Mt. Sapporodake, Prov. Isikari (Fig. 194). Three of them are clearly satellited, and the other members are also apparently duplicated, suggesting the probability that the material is of a polyploid nature.

**152. *Polygonatum hondoense* Nakai(?)  $n=11$ (PG), Fig. 200. Kamo, Prov. Uzen.**

The chromosomes of the haploid complement in the pollen grain vary in length to a certain extent, ranging from  $7.5\mu$  to  $3.0\mu$ . All the chromosomes are subterminal-inserted, with the exception of the smallest chromosome which has a nearly submedian insertion, and two large chromosomes are characterized by secondary constrictions. At prophase of the first vegetative division in the pollen grain, these two chromosomes are found to be associated with the nucleolus at the secondary constrictions (MATSUURA 1935)<sup>1)</sup>.

According to HASEGAWA (1930)<sup>2)</sup>, there are known 9 and 10 haploid chromosome numbers in the genus *Polygonatum*. The present material will be interesting in that it presents still another basic number, 11.

1) MATSUURA, H., Bot. & Zool., 3 (1935), 1589-94.

2) HASEGAWA, N., Bot. Mag. (Tokyo), 47 (1933), 901-3.

**153. *Polygonatum humile* Fisch.  $2n=20$ (RT), Fig. 201. Mt. Teine, Prov. Isikari.**

In the somatic complement, the chromosomes show a certain range of variation in length, approximately from  $7\mu$  to  $3\mu$ . The insertions are submedian in 3 pairs, and subterminal in 7 pairs, 2 of which have secondary constrictions.

The reduced number 10 has been given by HASEGAWA (1930)<sup>1)</sup> for this species.

**154. *Polygonatum lasiniathum* Maxim.  $n=10$ (PMC), Fig. 202. Mt. Gassan, Prov. Uzen.**

The 10 bivalents are similar with those of *P. Maximowiczii* (No. 155). HASEGAWA (1933)<sup>1)</sup> gives the same haploid number for this species.

**155. *Polygonatum Maximowiczii* Fr. Schm.  $n=10$ (PG), Fig. 198; (PMC), Fig. 199. Moiwa, Prov. Isikari.**

The haploid complement apparently consists of 3 submedian and 7 subterminal chromosomes. As in *P. hondoense*(?) and *P. humile*, two long chromosomes are provided with secondary constrictions, but these are different from those in the other species in that the secondary constrictions locate very closely to the primary insertion. MATSUURA (1935)<sup>2)</sup> has shown that these chromosomes are associated with the nucleolus at prophase in a similar way to that in *P. hondoense*(?).

At meiosis 10 bivalents are clearly visible, though the individual chromosomes are hardly discernible.

**156. *Convallaria Keiskei* Miq.  $n=19$ (PG), Fig. 204. Simamatu, Prov. Isikari.**

**157. *Convallaria majalis* L.  $n=19$ (PMC), Fig. 203. Cult.**

The chromosomes in the pollen grain of *C. Keiskei* are of average size, varying from about  $10\mu$  to  $5\mu$  in length. The insertions are submedian in 14 chromosomes and subterminal in 5, one of which is furnished with a satellite.

• The meiotic divisions in *C. majalis* take place in the normal fashion. At MI, each bivalent is conditioned by random chiasmata throughout the

1) HASEGAWA, N., Bot. Mag. (Tokyo), 47 (1933), 901-3.

2) MATSUURA, H., Bot. & Zool., 3 (1935), 1589-94.

length. In some individuals a few extra fragments were visible in addition to the normal complement.

Previous workers dealing with *Convallaria* all report  $n=16$  or  $18$  (cf. GAISER, 1930)<sup>1)</sup>. Stow (1934)<sup>2)</sup> describes likewise a triploid form of *C. Keiskei* which has a constitution of  $18$ . The present finding is not in accordance with these results as to the chromosome number.

**158. *Reineckia carnea* Kunth  $2n=38$ (RT), Fig. 205. Kamakura, Prov. Sagami.**

The 38 somatic chromosomes of the complement show a slight variation in size. Most of them have the insertions either median or submedian. No satellited chromosome was found. NAKAJIMA (1934)<sup>3)</sup> gives the same diploid counts for this species, while HOSONO (1934)<sup>4)</sup> reports 42 chromosomes.

**159. *Rhodea japonica* Roth.  $2n=38$ (RT), Fig. 206. Cult.**

The somatic complement of this species bears a close resemblance to that of *Reineckia carnea*, but differs at least from the latter in having one pair of chromosomes which have submedian insertions and are provided with secondary distal constrictions. Furthermore one of the pair in question bears a fairly large satellite.

For the same species, TAKAMINE (1916)<sup>5)</sup> gives  $n=14$  and YAMAMOTO (1930)<sup>4)</sup> reports  $2n=36$ . These counts are not in accordance with the present finding.

**160. *Liriope minor* Makino  $n=18$ (PMC), Fig. 208. Yunota, Prov. Uzen.**

The meiotic chromosomes are all similar in size and configurations. No characteristic features have been observed. SHIMOTOMAI (1927)<sup>6)</sup> gives  $n=ca. 36$  for a variety of *Liriope graminifolia*.

**161. *Ophiopogon Jaburan* Lodd.  $2n=36$ (RT), Fig. 207. Kamakura, Prov. Sagami.**

The chromosomes of the somatic complement vary in length, and can

1) GAISER, L. O., *Bibl. Gen.*, **6** (1930), 171-466.

2) STOW, I., *Trans., Sapporo Nat. Hist. Soc.*, **13** (1934), 190-5.

3) NAKAJIMA, G., *Jap. Journ. Gen.*, **9** (1933), 1-5.

4) cf. KIHARA, H., S. YAMAMOTO & S. HOSONO, *植物染色體数の研究* (1931).

5) TAKAMINE, N., *Bot. Mag. (Tokyo)*, **30** (1916), 293-303.

6) SHIMOTOMAI, N., *Bot. Mag. (Tokyo)*, **41** (1927), 149-60.

be grouped into three size classes; 2 very long chromosomes with median insertions, 6 long ones with subterminal insertions and 20 medium or short ones with subterminal insertions. Two subterminal chromosomes of the last are also characterized by large satellites.

DUDGEON (1922)<sup>1)</sup> reports the haploid number of 56 in *Ophiopogon intermedium*, a quite different chromosomal situation from the present case.

**162. *Crinum asiaticum* L. var. *japonicum* Baker 2n=22(RT), Fig. 209. Cult.**

The chromosomes of the somatic complement are fairly large, and vary a little in length. The insertions are median in 3 pairs, submedian in 3 pairs, subterminal in 4 pairs, and 1 pair is characterized by secondary constrictions. The same counts of chromosomes have been given by NAGAO & TOKUNAGA (1932) for the same species.

**163. *Agave americana* L. var. *marginata* Hort. 2n=60(RT), Fig. 210. Cult.**

The somatic complement consists of two types of chromosomes which differ strikingly in their size from each other, namely, 10 very long chromosomes of nearly equal size (ca. 3–4 $\mu$ ) and 50 very short ones of somewhat variable size (ca. 0.5–1.2 $\mu$ ). The long chromosomes all have extremely subterminal insertions, while in the short chromosome group, some have the insertions nearly median and others subterminal.

The present finding confirms the previous observations made by MACKELVEY & SAX (1933)<sup>3)</sup> and WHITAKER (1934)<sup>4)</sup> in other species of *Agave*.

**164. *Marica Northiana* Ker. 2n=18(RT), Fig. 211. Cult.**

The chromosomes of the somatic complement are very slender, clearly median-inserted in 7 pairs and submedian in 2 pairs.

**165. *Musa Cavendishii* Lamb. 2n=32+2ff(?) (RT), Fig. 212. Cult.**

The chromosomes are all short and show some variation in size. Their insertions are not very distinct.

WHITE (1928)<sup>5)</sup> reported 2n=32 in the same species. According to

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- 1) DUDGEON, W., Journ. Proc. Asiat. Soc. Bengal N. S., 18 (1922), 95–124.
  - 2) NAGAO, S. & H. TOKUNAGA, Bot. Mag. (Tokyo), 46 (1932), 473–8.
  - 3) MACKELVEY, S. D. & K. SAX, Journ. Arnold Arb., 14 (1932), 76–81, pl. LV.
  - 4) WHITAKER, T. W., Journ. Arnold Arb., 15 (1934), 135–43.
  - 5) WHITE, P. R., Zeitschr. Zellforsch. Mikrosk. Anat., 7 (1928), 673–733.

him (1928) and CHEESMAN & LASTER (1935),<sup>1)</sup> *Musa* has either 8 or 11 chromosomes as the basic number, and therefore his material will be a tetraploid form. In the present material, two chromosomes in the complement are distinctly shorter than the rest; probably they are fragments.

**166. *Orchis Fauriei* Finet.  $2n=21$  (Archeporium), Fig. 214. Mt. Zaô, Prov. Uzen.**

The somatic complement was observed in the division of archesporic cells. It consists of 3 long chromosomes with submedian insertions, 6 medium long chromosomes with submedian and subterminal insertions each and 6 short chromosomes with submedian insertions. It is then most probable that the present material is a triploid form.

**167. *Epipactis papillosa* Fr. & Sav.  $n=20$  (PMC), Fig. 213, Mt. Moiwa, Prov. Isikari.**

The chromosomes at the first metaphase of the PMC are easily divided into two types according to their size, i.e., 4 large and 14 short bivalents. The large bivalents are ring-shaped and the short ones generally of rod-shape.

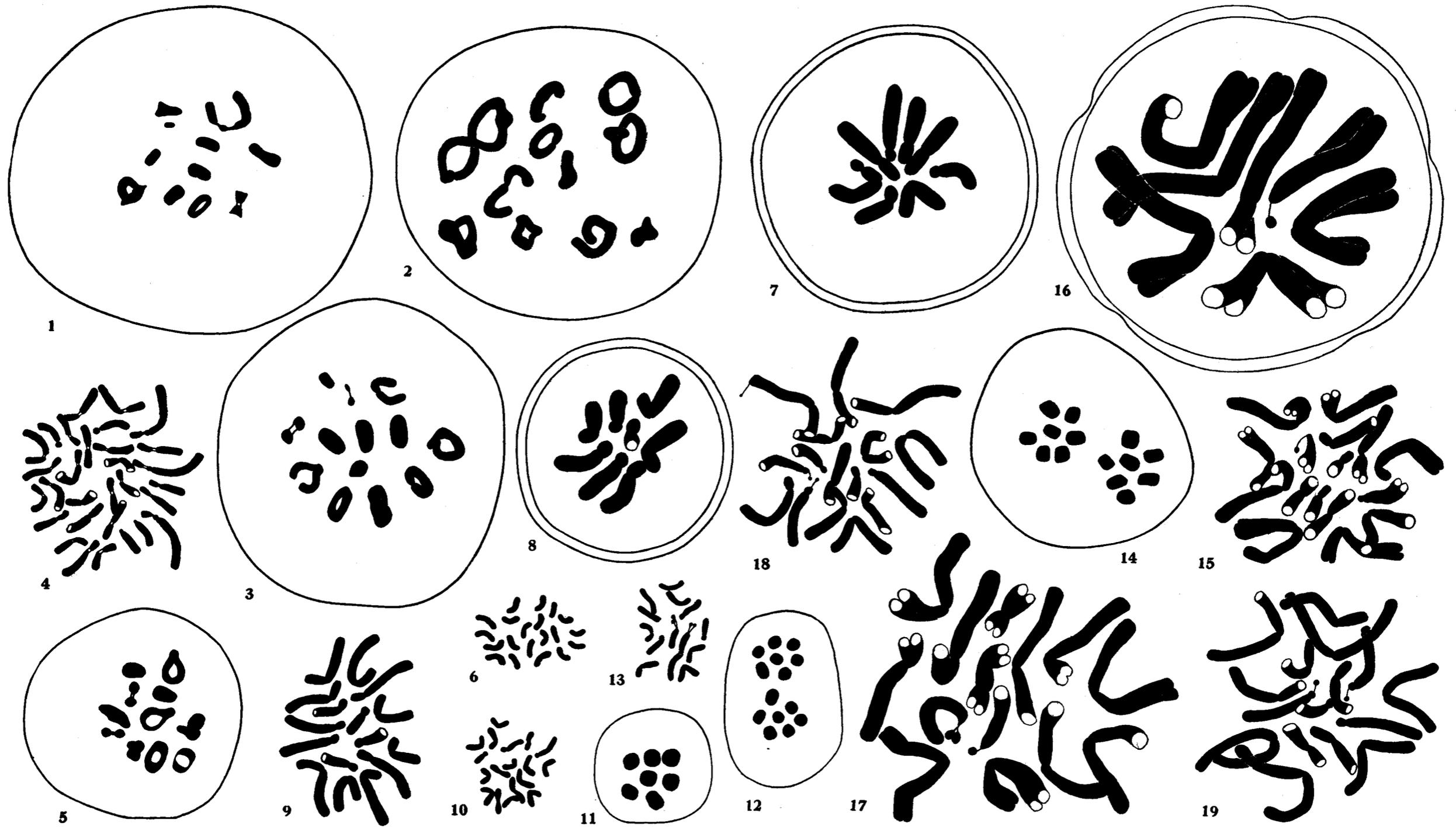
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1) CHEESMAN, E. E. & L. N. H. LASTER, *Journ. Gen.*, **30** (1925), 31-53.

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## Plate V.

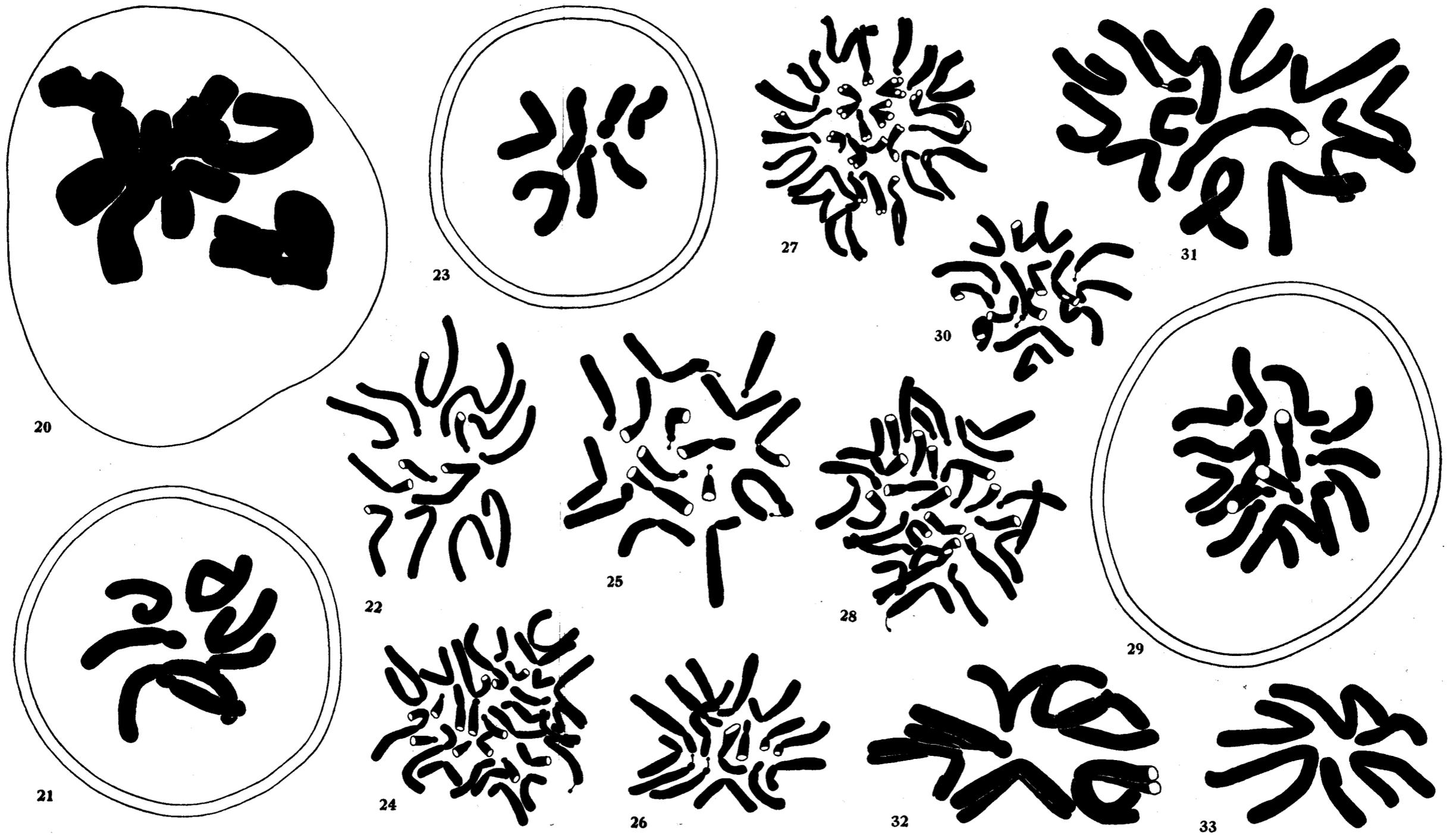
- 1, 2. *Taxus cuspidata* SIEB. & ZUCC. ♂. PMC. S. MI.
3. *Taxus cuspidata* SIEB. & ZUCC. ♀. PMC. S. MI.
4. *Chloranthus glaber* MAKINO RT. P.
5. *Silene schafta* GMEL. PMC. S. MI.
6. *Glaucidium palmatum* SIEB. & ZUCC. RT. P. stained by Heidenhain's iron haematoxylin Method.
7. *Trollius acaulis* LINDL. PG. A.
8. *Trollius europaeus* L. PG. A.
9. *Trollius purpuratus*. RT. P.
10. *Coptis japonica* MAKINO RT. P.
- 11, 12, 13. *Thalictrum aquilegifolium* L. PMC. MI (Fig. 11), MII (Fig. 12), RT (Fig. 13), P.
14. *Thalictrum yezoense* NAKAI PMC. A.
15. *Anemone japonica* SIEB. RT. P.
16. *Anemone flaccida* FR. SCHM. PG. A.
17. *Hepatica triloba* var. *obtusa* ALPH. WOOD. RT. P.
18. *Pulsatilla cernua* SPRING RT. P.
19. *Trautvetteria japonica* SIEB. & ZUCC. RT. P.



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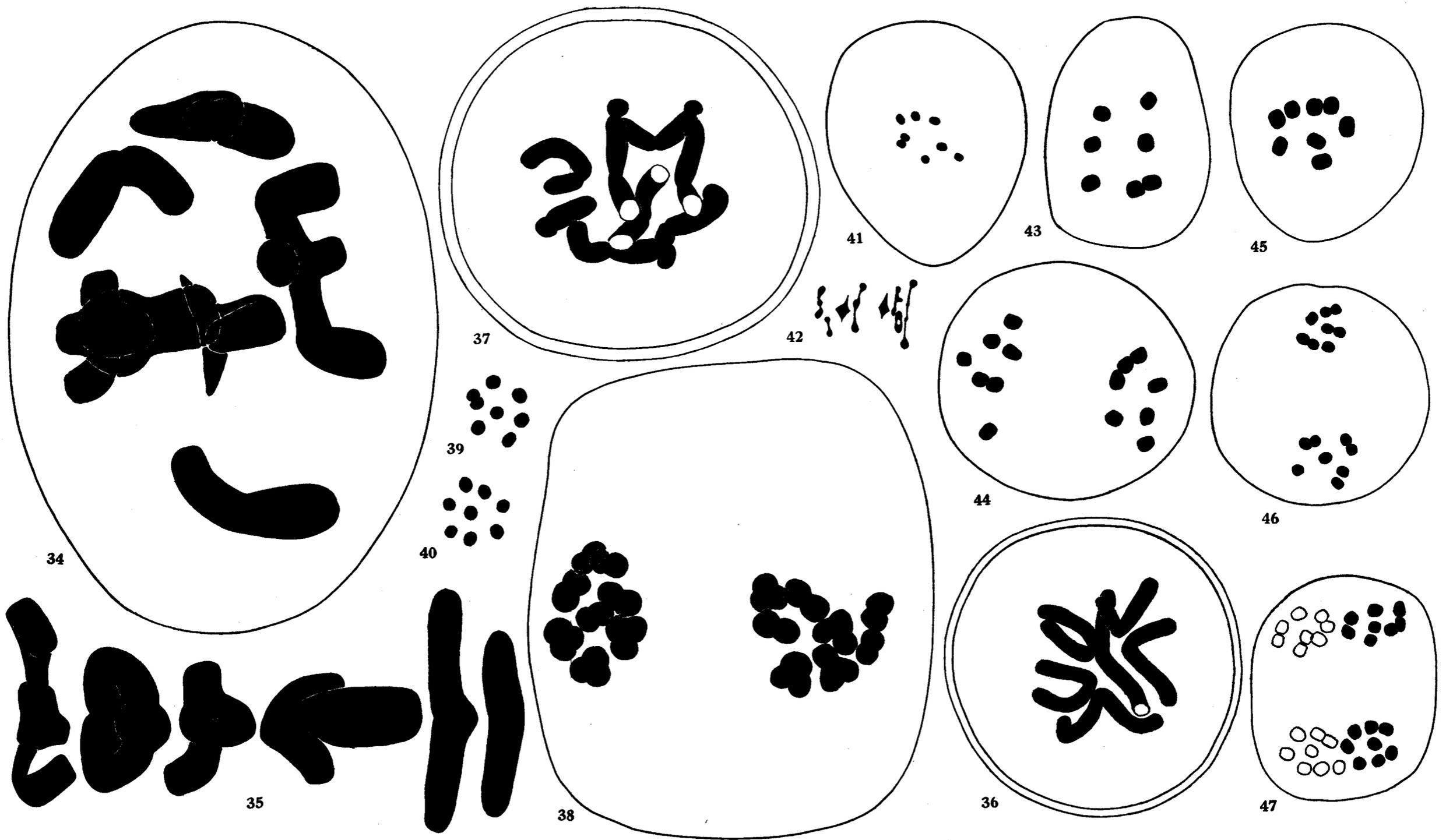
## Plate VI.

20. *Trautvetteria japonica* SIEB. & ZUCC. PMC. A. MI.
21. *Ranunculus acris* var. *frigidus* REGEL PG. A.
22. *Ranunculus acris* var. *Steveni* REGEL RT. P.
23. *Ranunculus bulbosus* L. PG. A.
24. *Ranunculus Flammule* L. RT. P.
25. *Ranunculus hakkodensis* NAKAI RT. P.
26. *Ranunculus Vernyi* FR. & SAV. RT. P.
27. *Ranunculus Kernerii* FREY. RT. P.
28. *Ranunculus repens* L. RT. P.
29. *Ranunculus repens* var. *major* NAKAI PG. A.
30. *Ranunculus quelpaertensis* NAKAI RT. P.
31. *Ranunculus* sp. PG. A.
- 32, 33. *Diphylleia Grayi* FR. SCHM. PMC. MII. A.



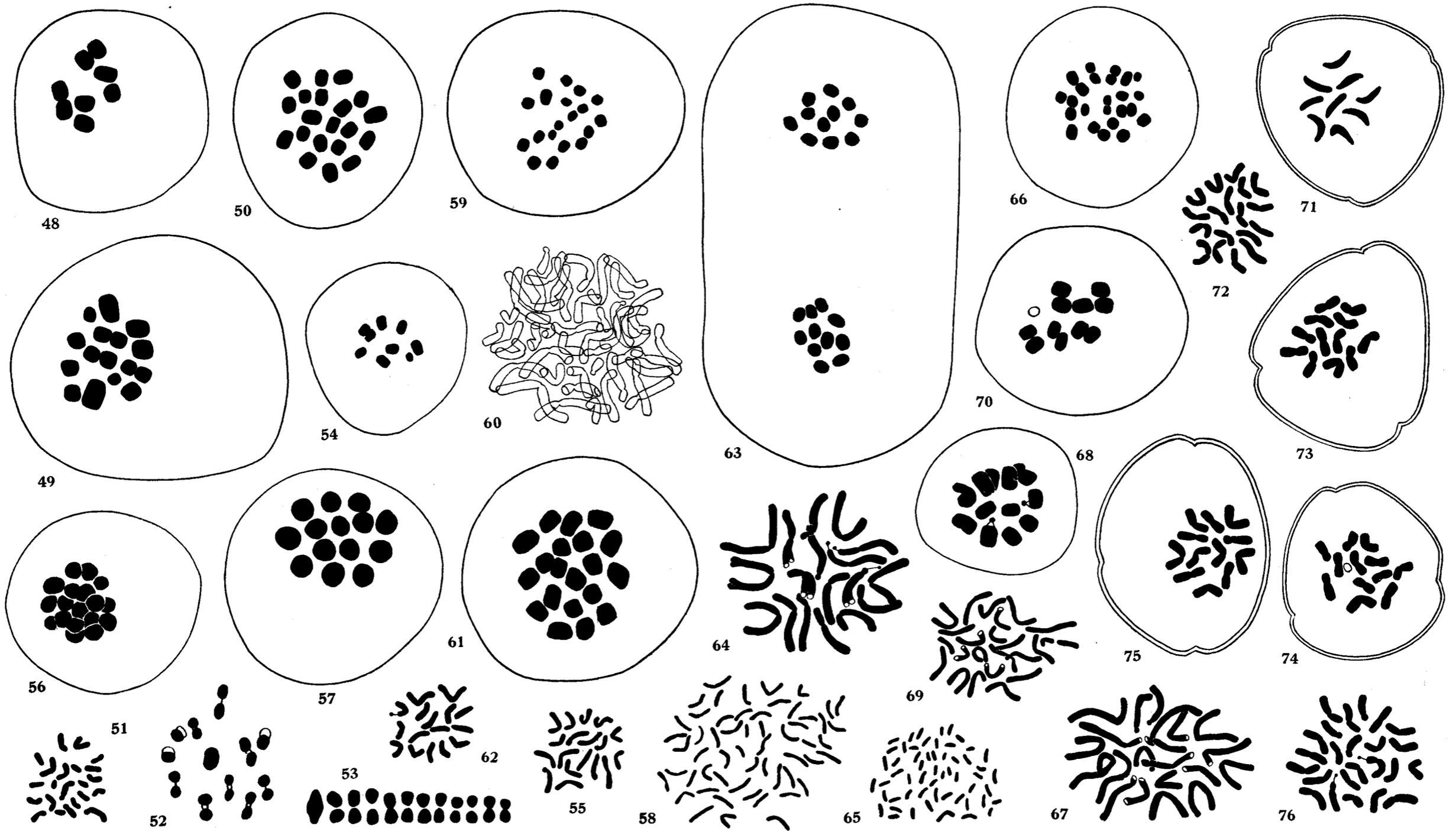
## Plate VII.

- 34, 35. *Diphylleia Grayi* FR. SCHM. PMC. MI. A.  
36. *Achlys japonica* MAXIM. PG. A.  
37, 38. *Caulophyllum robustum* MAXIM. PMC. Ana(Fig. 38), PG(Fig. 37). A.  
39, 40. *Dicentra spectabilis* MIQ. PMC. MI. S.  
41, 42. *Dicentra pusilla* FR. & SAV. PMC. MI. S.  
43, 44. *Cochlearia oblongifolia* DC. PMC. A. MI(Fig. 43). MII(Fig. 44).  
45-47. *Barbarea hondoense* NAKAI PMC. S. MI(Fig. 45). MII(Fig. 46).  
Ana II(Fig. 47).



## Plate VIII.

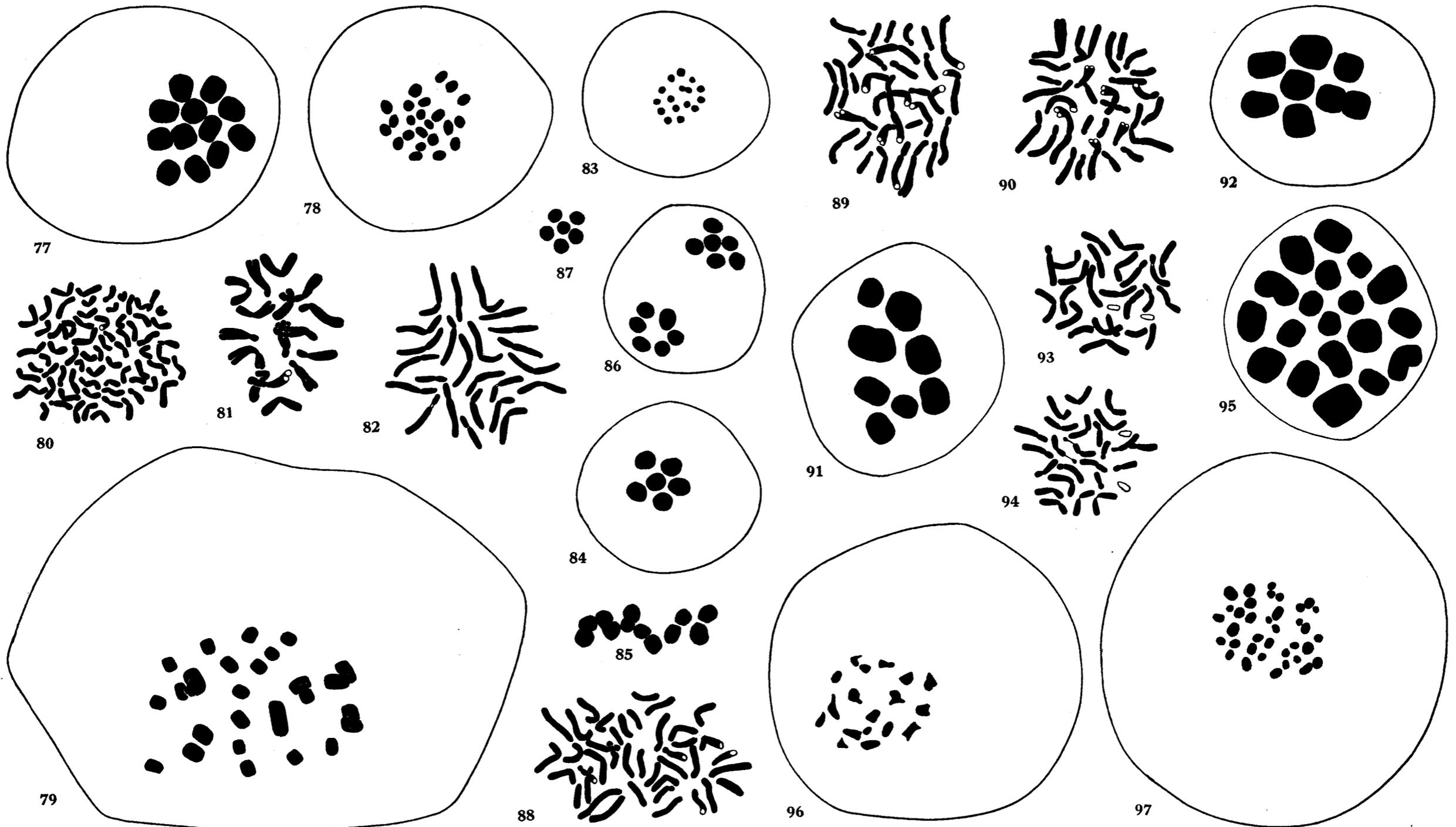
48. *Barbarea patens* BOISS. PMC. A. MI.
49. *Arabis iwatensis* MAKINO PMC. A. MI.
50. *Saxifraga sachalinensis* FR. SCHM. PMC. A. MI.
51. *Saxifraga mutabilis* KOIDZ. RT. P.
- 52, 53. *Chrysosplenium fragelliferum* FR. SCHM. PMC. A. MI.
54. *Triarella polyphylla* D. DON PMC. A. MI.
55. *Parnassia palustris* var. *multiseta* LEDEB. RT. P.
56. *Hydrangea petiolaris* SIEB. & ZUCC. PMC. A. MI.
57. *Schizophragma hydrangeoides* SIEB. & ZUCC. PMC. A. MI.
58. *Sanguisorbia albiflora* MAKINO RT. P.
59. *Amorpha fruticosa* L. PMC. S. MI.
60. *Oxalis japonica* FR. & SAV. RT. P.
61. *Euphorbia splendens* BOJ. PMC. A. MI.
62. *Hypericum senanense* MAXIM. RT. P.
63. *Opuntia polyacantha* HAW. PMC. S. MII.
64. *Daphne jezoensis* MAXIM. RT. P.
65. *Melastoma sanguineum* SIMS. RT. P.
66. *Panax japonicum* C. A. MEY. PMC. S. MI.
67. *Ligustrum japonicum* MAXIM. RT. P.
- 68, 69. *Cnidium ajaense* DRUDE PMC. S. MI (Fig. 68). RT (Fig. 69). P.
70. *Heracleum lanatum* MICHX. PMC. S. MI.
- 71, 72. *Primula Fauriae* FRANCH. PG (Fig. 71). S. RT (Fig. 72). P.
- 73, 74. *Primula jesoana* MIQ. PG. S.
75. *Primula Sieboldii* MORR. PG. A.
76. *Primula kisoana* MIQ. RT. P.



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## Plate IX.

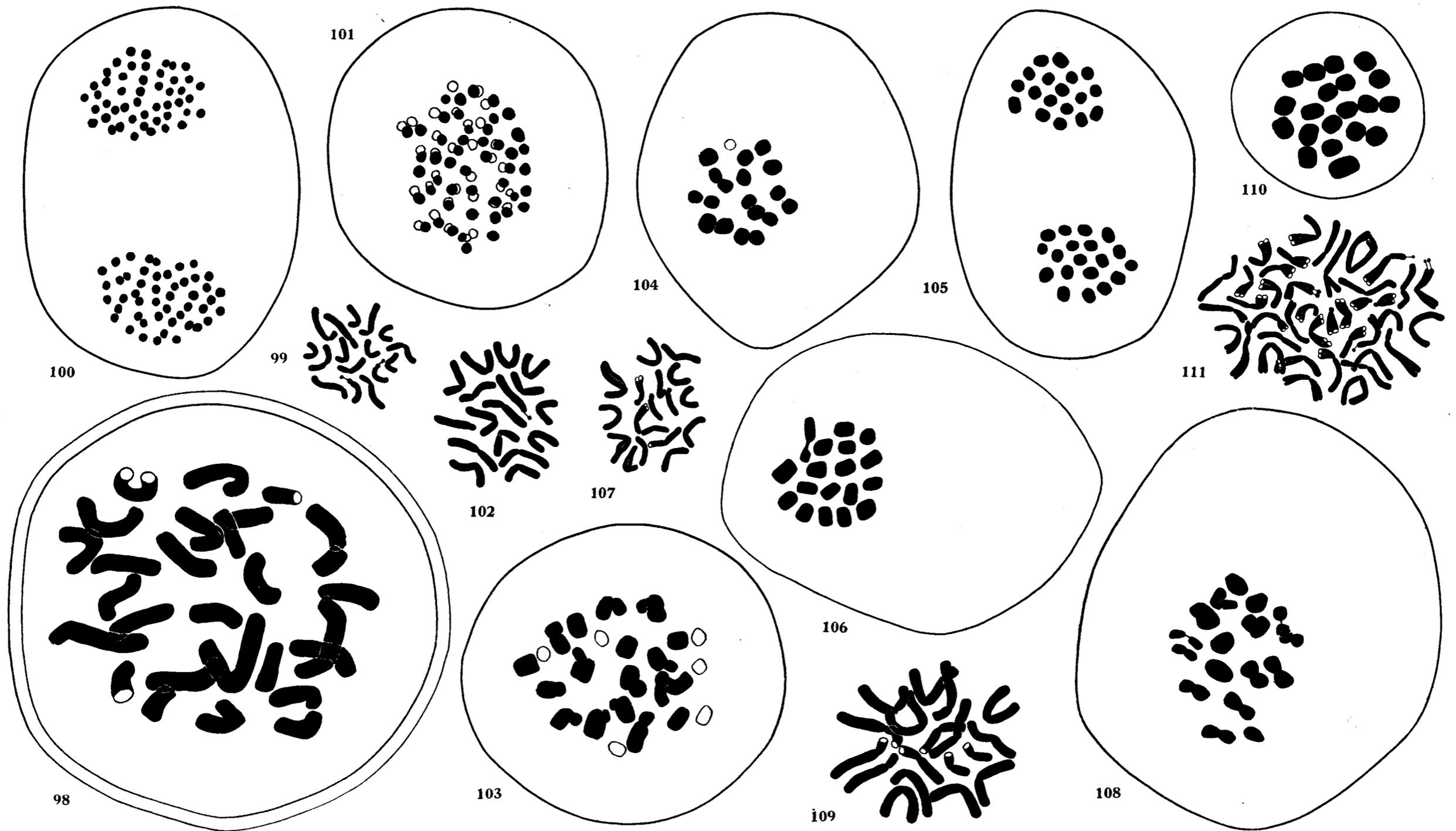
77. *Cortusa Matthioli* L. PMC. A. MI.
78. *Ligustrum yesoense* NAKAI PMC. S. MI.
79. *Menyanthes trifoliata* L. PMC. A. S. MI.
80. *Fauria Crista-galli* MAKINO RT. P.
81. *Lithospermum Zollingeri* A. DC. RT. P.
82. *Solanum grandiflorum* HORT. RT. P.
83. *Verbascum phoeniceum* L. PMC. S. MI.
- 84, 85. *Linaria albata* F. G. DIETER PMC. S. MI.
- 86, 87. *Linaria dalmatica* MILL. PMC. S. MII.
88. *Pentstemon frutescens* LAMB. RT. P.
- 89, 90. *Pedicularis apodochila* MAXIM. RT. P.
- 91, 92. *Pedicularis japonica* MIQ. PMC. fixed by Carnoy's fluids. P. MI.
- 93, 94. *Plantago Mohnikei* MIQ. RT. P.
95. *Sambucus Buergeriana* BL. var. *Miquelii* NAKAI PMC. P. MI.
96. *Lonicera sempervirens* L. PMC. S. MII.
97. *Lonicera* sp. PMC. S. MI.



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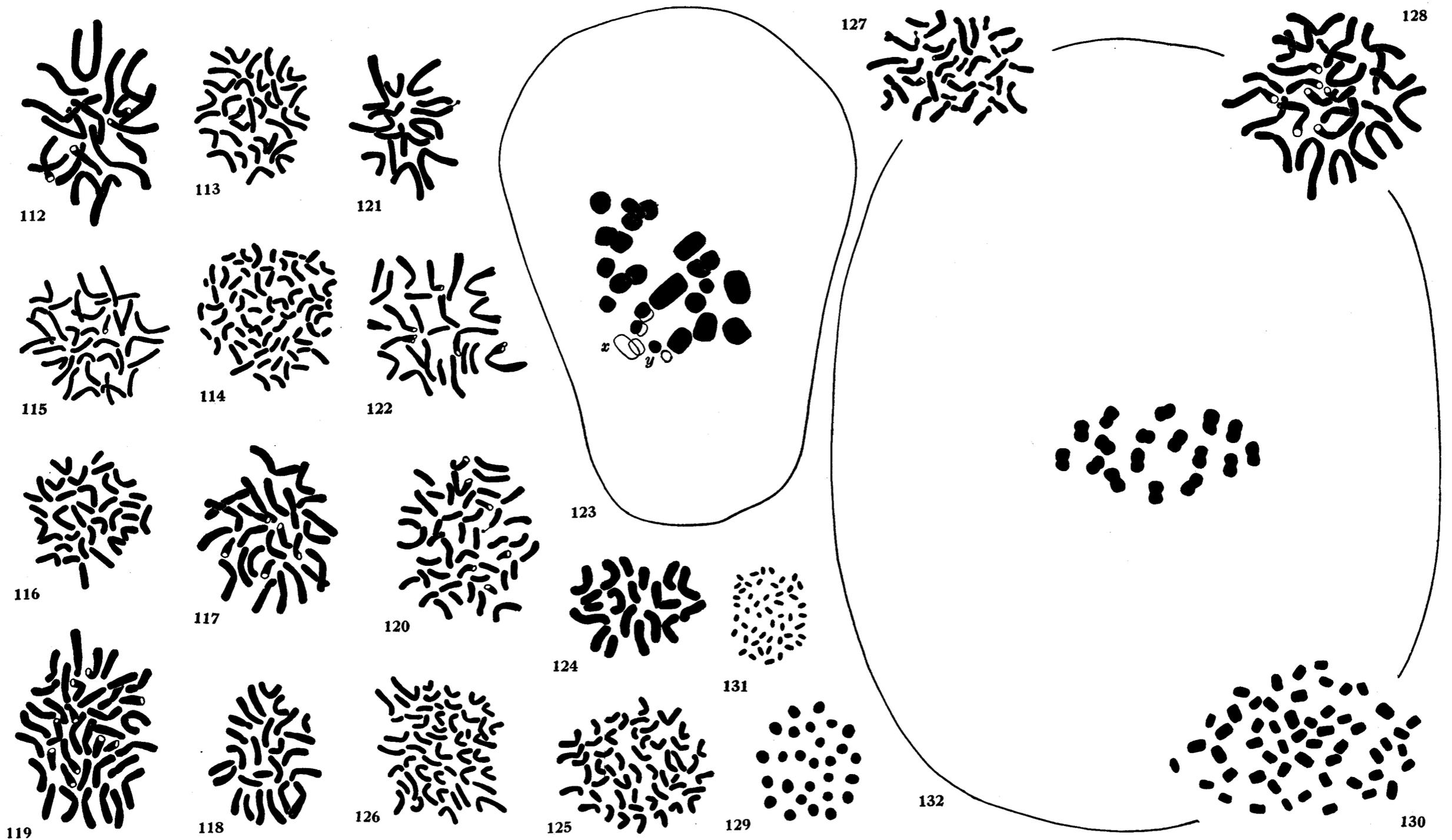
## Plate X.

98. *Adoxa Moschatellina* L. PG. A.  
99. *Valeriana flaccidissima* MAXIM. RT. P.  
100, 101. *Campanula alliariaefolia* WILLD. PMC. S. MI(Fig. 101). MII  
(Fig. 100).  
102, 103. *Adenophora hakusanensis* NAKAI PMC. S. MI(Fig. 103). PG  
(Fig. 102). A.  
104, 105. *Adenophora remotiflora* MIQ. PMC. S. MI(Fig. 104). MII(Fig.  
105).  
106. *Adenophora Thunbergiana* forma *hirsuta* KUDO PMC. S. MI.  
107. *Solidago japonica* var. *alpicola* KIT. RT. P.  
108. *Erigeron glabratus* HOP. & HORNS. PMC. fixed by Carnoy's fluid.  
P. MI.  
109. *Artemisia sinanensis* YABE RT. P.  
110, 111. *Senecio nemorensis* L. PMC. P. MI(Fig. 110). RT(Fig. 111). P.



## Plate XI.

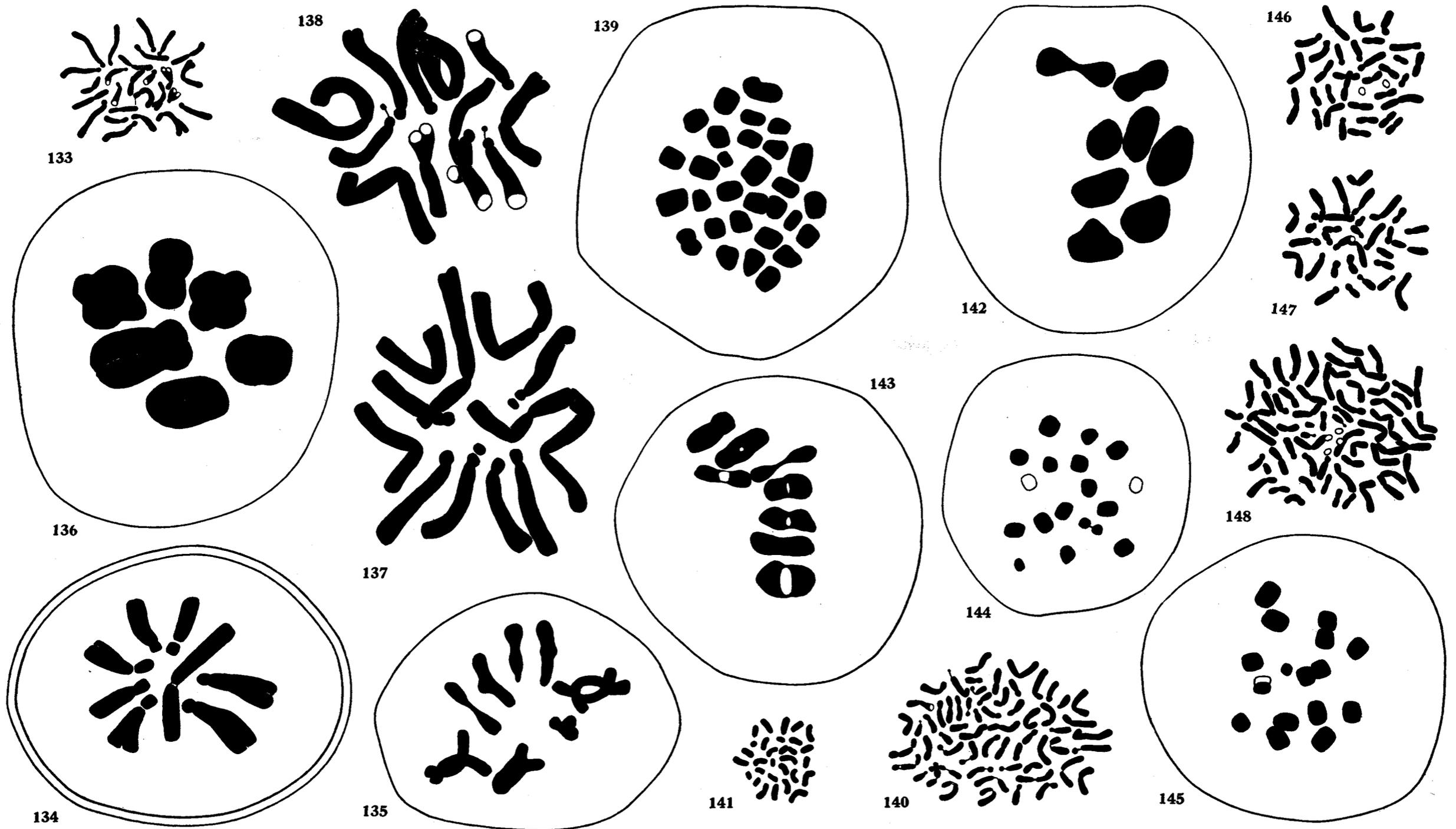
112. *Mallotopus japonicus* FR. & SAV. RT. P.
113. *Cirsium chokaiense* KITAMURA RT. P.
114. *Cirsium ganjuense* KITAMURA RT. P.
115. *Cirsium purpuratum* MATSUM. RT. P.
116. *Cirsium ugoense* NAKAI RT. P.
117. *Saussurea brachycephala* FRANCH. RT. P.
118. *Saussurea sagitta* FRANCH. RT. P.
119. *Saussurea Riederi* var. *japonica* KOIDZ. RT. P.
120. *Gerbera Anandria* SCHULTZ RT. P.
121. *Hieracium japonicum* FR. & SAV. RT. P.
122. *Taraxacum hondoense* NAKAI RT. P.
123. *Helodea densa* CASP. PMC. S. MI.
124. *Glyceria pallida* TRIN. RT. P.
125. *Hackonecholla macra* MAKINO RT. P.
126. *Hackonecholla macra* var. *aureola* MAKINO RT. P.
127. *Philodendron Andreanum* DEV. RT. P.
128. *Alocasia macrorrhiza* SCHOTT RT. P.
129. *Belbergia Liboniana* D'JONGHE PMC. A. MI.
130. *Belbergia* sp. PMC. A. MI.
131. *Pitcarnia muscosa* MAST. RT. P.
132. *Cryptanthus acaulis* BEER PMC. A. MI.



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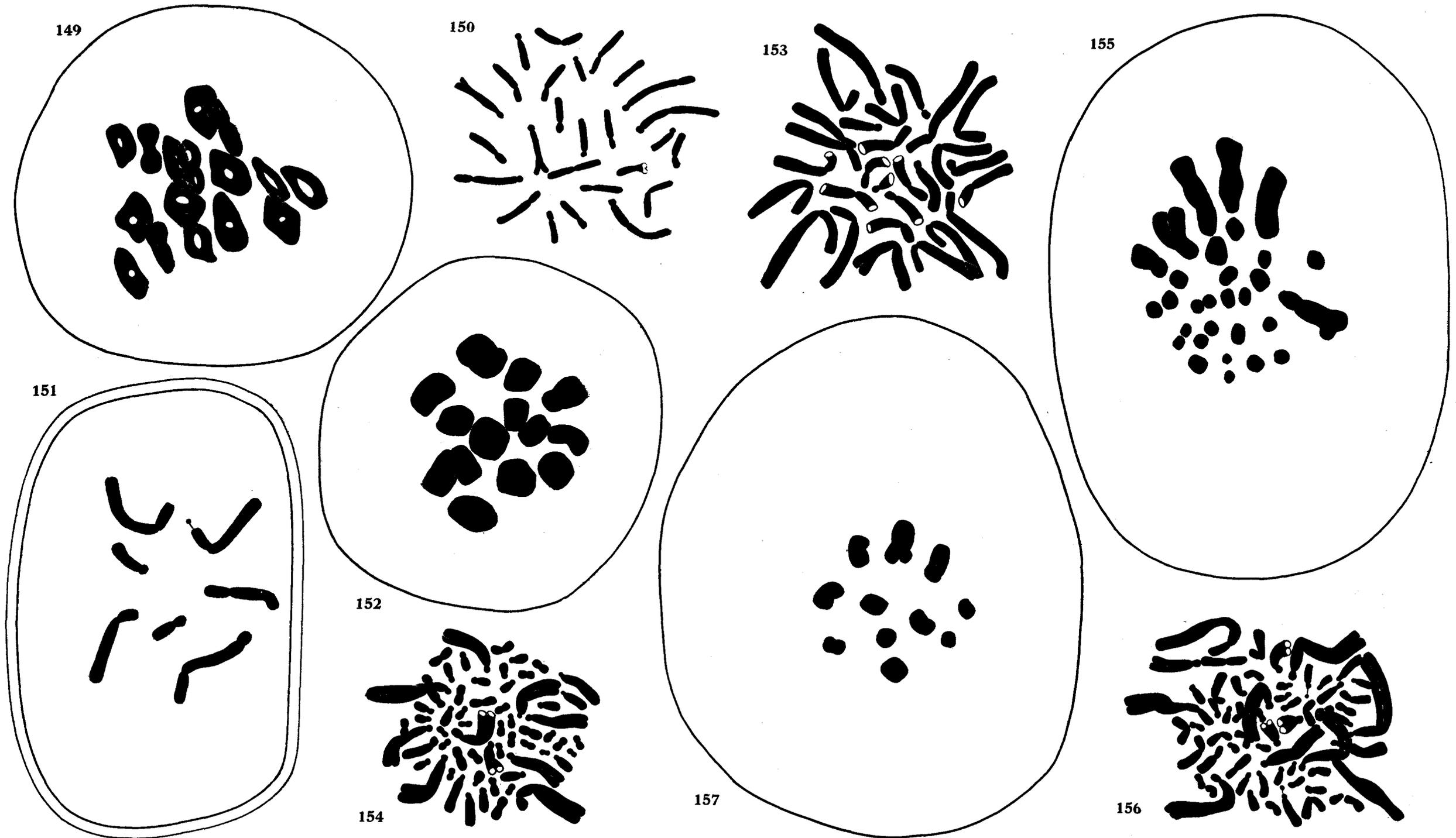
## Plate XII.

133. *Cyanoptis somaliensis* CLARKE RT. P.  
134, 135. *Tradescantia amplexicaulis*. PMC. S. MI(Fig. 135). PG(Fig. 134). S.  
136-138. *Spirocnema fragrans* LINDL. RT. P. (Figs. 137 and 138), PMC. A. MI(Fig. 136).  
139, 140. *Tofieldia japonica* MIQ. PMC. A. MI(Fig. 139), RT(Fig. 140). P.  
141. *Tofieldia nutans* WILLD. RT. P.  
142. *Veratrum longibracteatum* TAKEDA PMC. A. MI.  
143. *Veratrum Maximowiczii* BAK. PMC. A. MI.  
144, 145. *Veratrum oxysepalum* TURCZ. PMC. S. MI.  
146-148. *Veratrum stramineum* MAXIM. RT. P.



### Plate XIII.

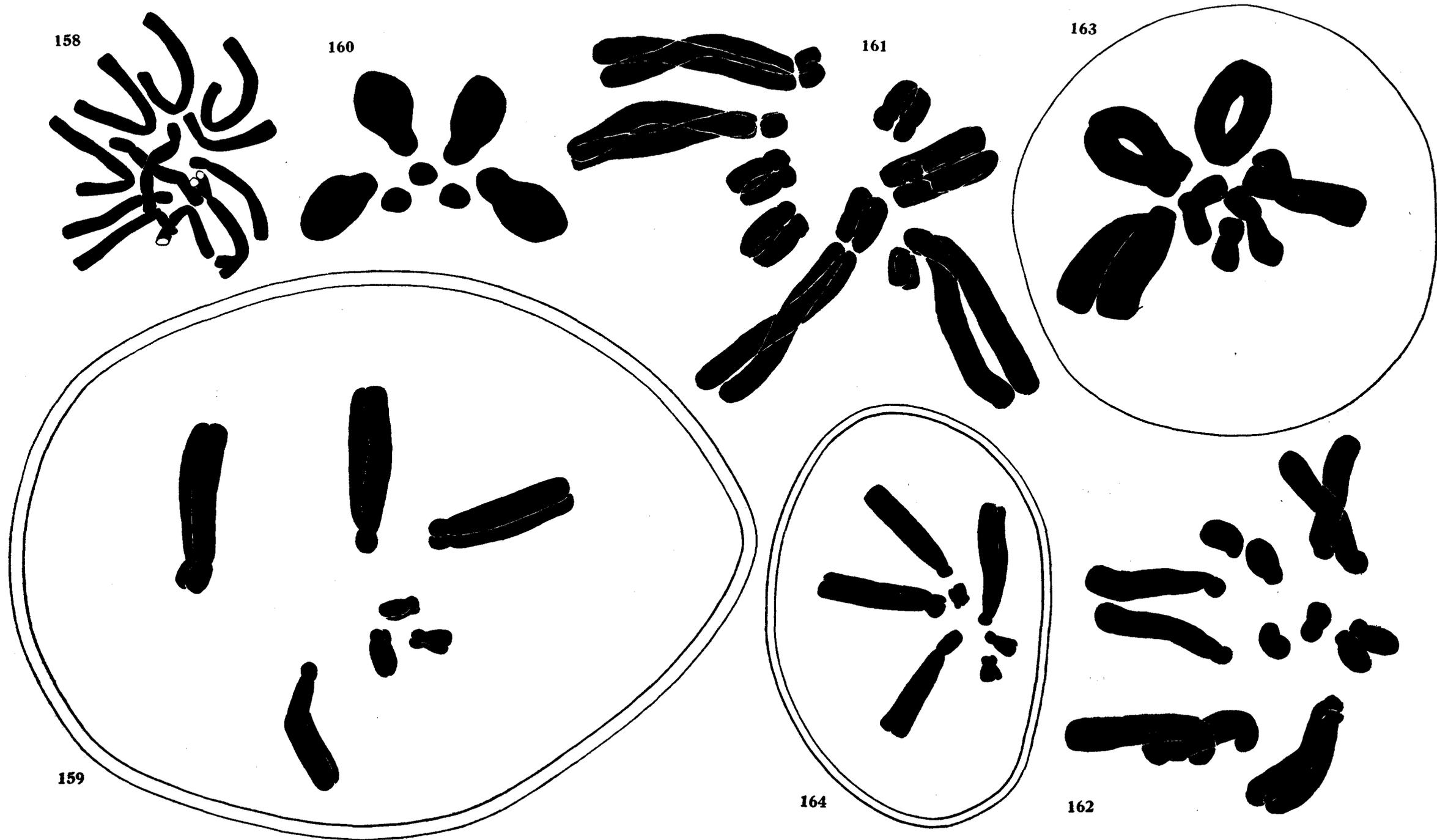
149. *Veratrum stramineum* MAXIM. PMC. A. MI.
150. *Tricyrtis latifolia* MAXIM. RT. P.
151. *Anthericum ciliatum* SPRING PG. S.
152. *Chlorophytum elatum* R. BR. PMC. S. MI.
153. *Chlorophytum elatum* var. *variegatum* HORT. RT. P.
154. *Hosta lacifolia* ENGL. RT. P.
155. *Hosta japonica* ASCHERS. & GRAEBN. PMC. S. MI.
156. *Hosta* sp. RT. P.
157. *Hermerocallis Dumortierii* MORR. PMC. S. MI.



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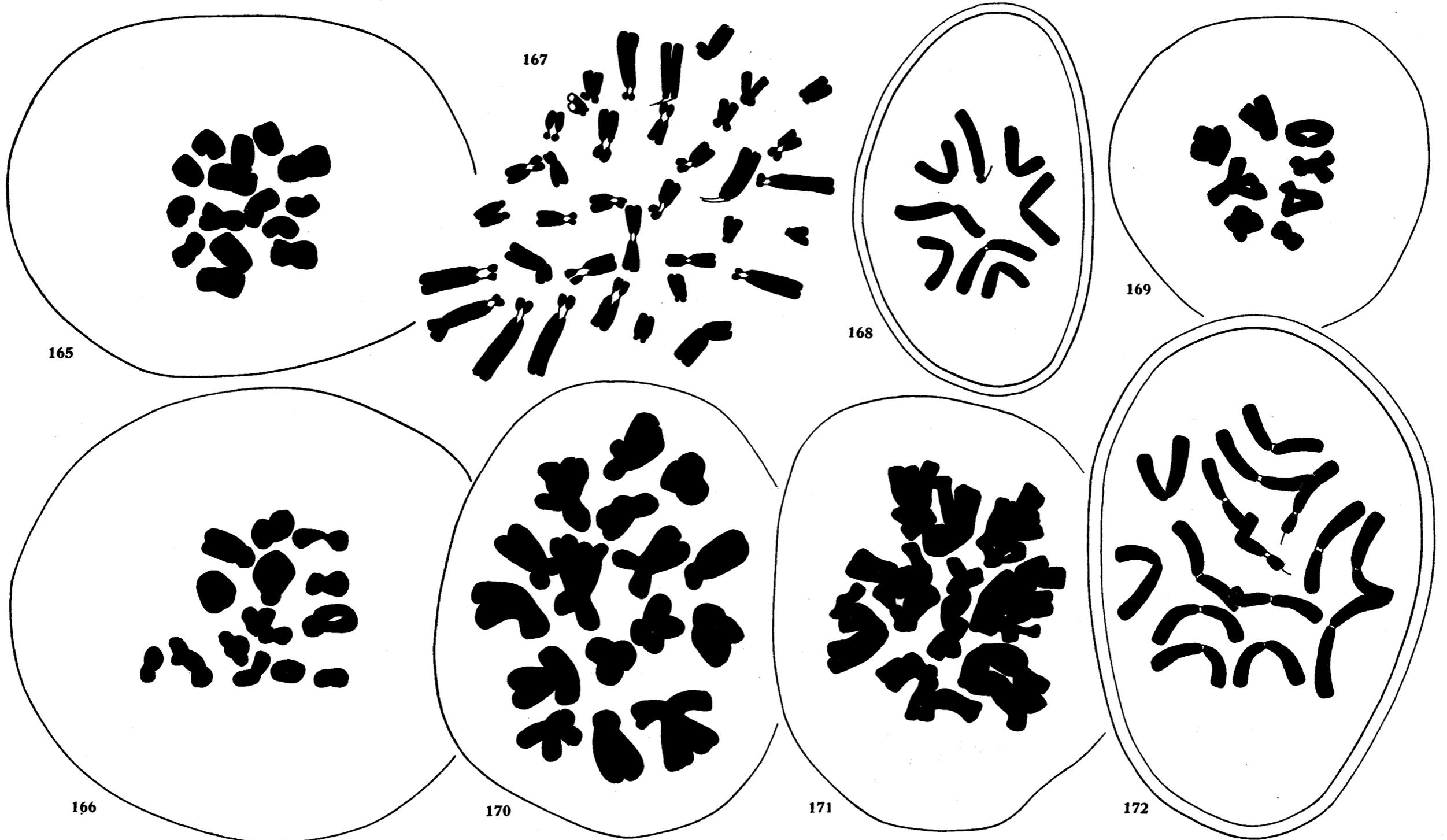
## Plate XIV.

158. *Kniphofia pulchella*. RT. P.  
159. *Aloe sp.* PG. S.  
160, 161. *Aloe sp.* PMC. S. MI(Fig. 160). PG(Fig. 161). S.  
162. *Gasteria sp.* PG. S.  
163, 164. *Haworthia sp.* PMC. A. MI(Fig. 163). PG(Fig. 164). S.



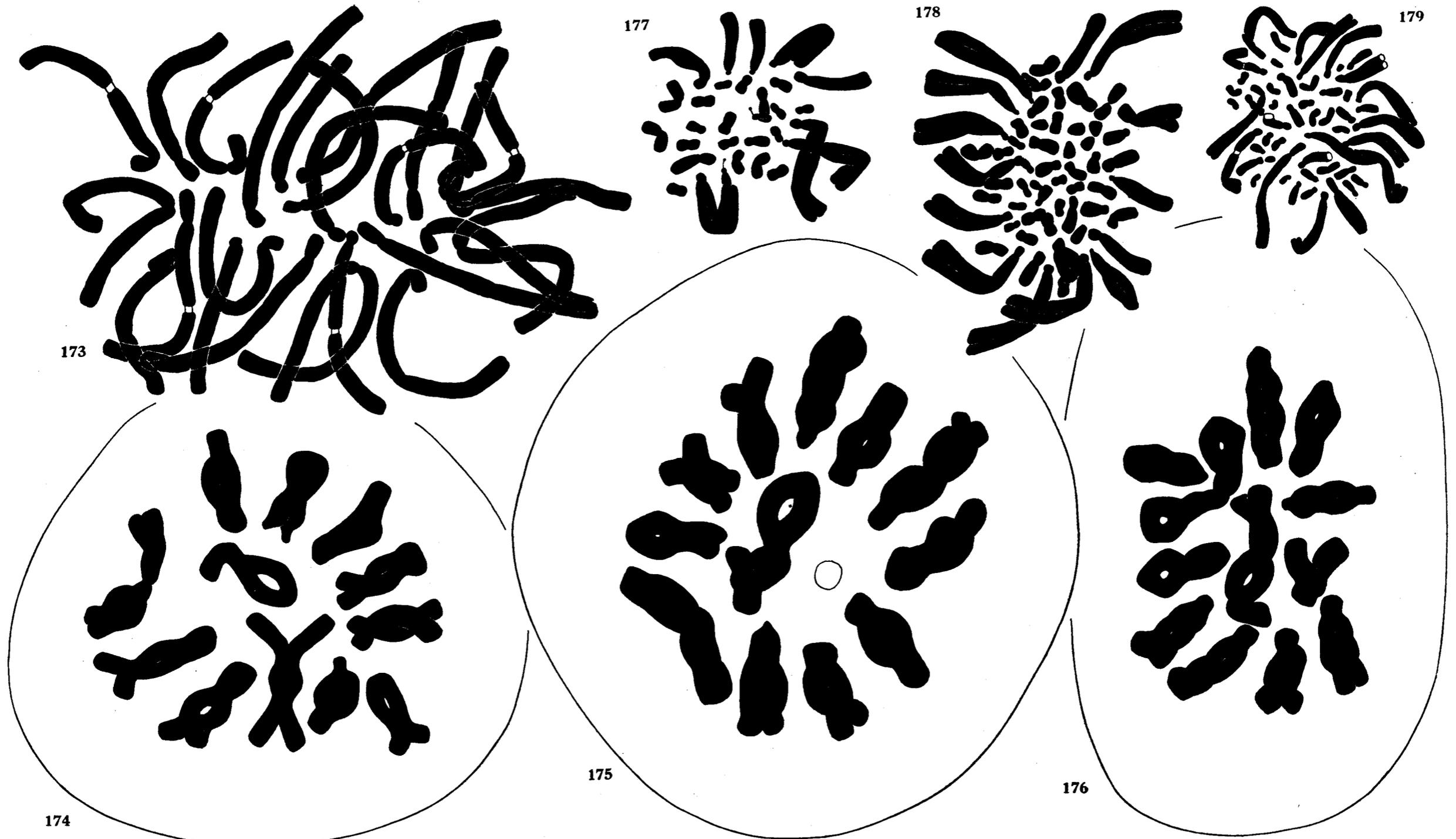
## Plate XV.

165. *Agapanthus excelsa*. PMC. S. MI.  
166. *Agapanthus umbellatus* L'HÉRIT. PMC. S. MI.  
167. *Gagea lutea* KER-GAWL. PG. A.  
168, 169. *Allium Schoenoprasum* var. *typicum* REGEL PMC. S. MI (Fig.  
169). PG (Fig. 168). S.  
170. *Allium Victorialis* L. subsp. *platyphyllum* HULTÉN PMC. S. MI.  
171, 172. *Nothoscordum fragrans* KUNTH PMC. S. MI (Fig. 171). PG  
(Fig. 172). S.



## Plate XVI.

- 173-175. *Lilium medeoloides* A. GRAY PMC. S. MI(Figs. 174 and 175).  
RT(Fig. 173). P.
176. *Cardiocrinum Glehni* MAKINO PMC. S. MI.
177. *Eucomis bicolor* BAKER RT. P.
178. *Eucomis punctatum* L. RT. P.
179. *Ornithogalum umbellatum* L. RT. P.



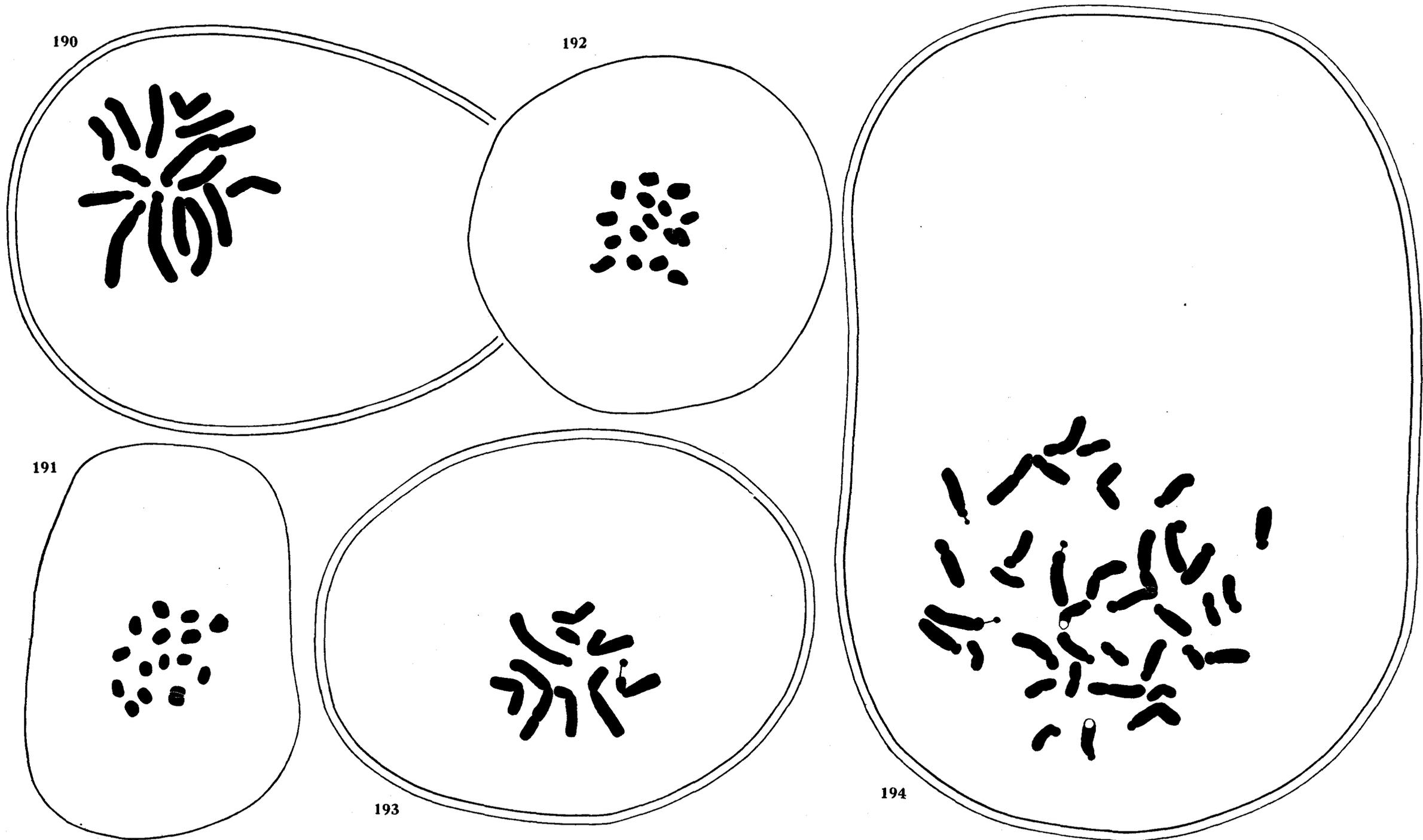
## Plate XVII.

180. *Drimiopsis botryoides* BAKER PMC. S. MI.
181. *Hyacinthus orientalis* L. PG. A.
182. *Muscari botryoides* MILL. PG. A.
183. *Yucca aloifolia* L. RT. P.
184. *Yucca Wrightii*. RT. P.
185. *Sansevieria zeylanica* WILLD. PMC. A. MI.
186. *Sansevieria zeylanica* var. *variegata* HORT. RT. P.
- 187, 188. *Cordyline australis* HOOK. PMC. A.
189. *Smilacina japonica* A. GRAY var. *mandshurica* MAXIM. PMC. S. MI.



## Plate XVIII.

- 190-192. *Streptopus amplexifolius* DC. PMC. S. MI (Figs. 191 and 192).  
PG (Fig. 190). A.
193. *Streptopus japonicus* OHWI PG. A.
194. *Streptopus streptoides* KOIDZ. PG. A.



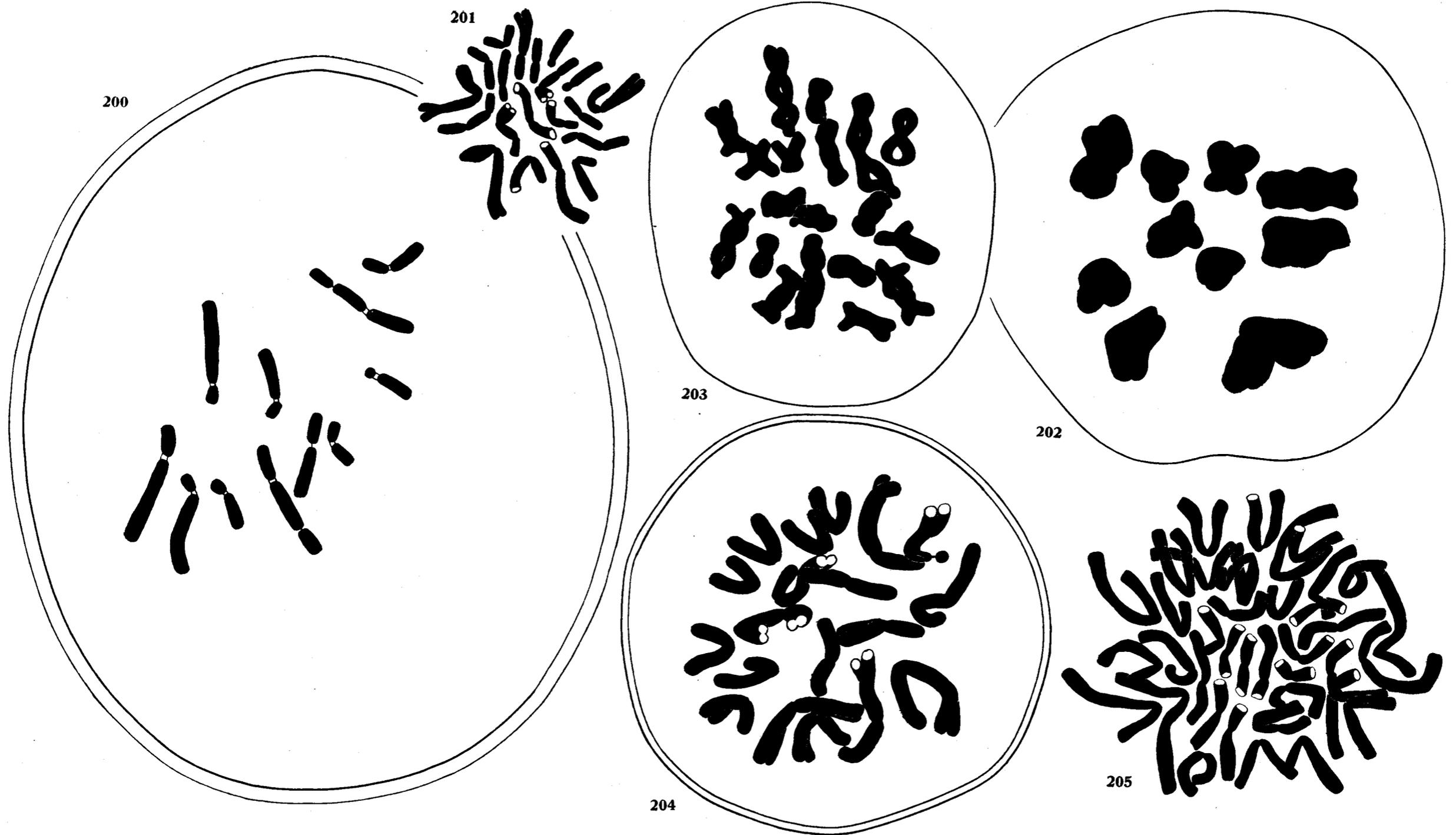
## Plate XIX.

195. *Clintonia udensis* TRAUTV. & MEY. PG. S.  
196. *Majanthemum dilatatum* VELLS. & MACB. PMC. S. MI.  
197. *Disporum sessile* D. DON var. *macrophyllum* KOIDZ. PG. A.  
198, 199. *Polygonatum Maximowiczii* FR. SCHM. PMC. S. MI (Fig. 199).  
PG (Fig. 198). S.



## Plate XX.

- 220. *Polygonatum hondoense* NAKAI? PG. S.
- 201. *Polygonatum humile* FISCHER RT. P.
- 202. *Polygonatum lasianthum* MAXIM. PMC. S. MI.
- 203. *Convallaria majalis* L. PMC. S. MI.
- 204. *Convallaria Keiskei* MIQ. PG. A.
- 205. *Reineckia carnea* KUNTH RT. P.



## Plate XXI.

- 206. *Rhodea japonica* ROTH RT. P.
- 207. *Ophiopogon Jaburan* LODD. RT. P.
- 208. *Liripe minor* MAKINO PMC. A. MI.
- 209. *Crinum asiaticum* L. var. *japonicum* BAKER RT. P.
- 210. *Agave americana* L. var. *marginata* HORT. RT. P.
- 211. *Marica Northiana* KER. RT. P.
- 212. *Musa Cavendishii* LAMB. RT. P.
- 213. *Orchis Fauriei* FINET. PMC. A. MI.
- 214. *Epipactis papillosa* FR. & SAV. PMC. A. MI.

