MEMOIRS OF THE COLLEGE OF SCIENCE, KYOTO IMPERIAL UNIVERSITY, SERIES B.
VOL. IV, NO. 3, ARTICLE 11, 1929.

Chromosome Arrangement.

III. The Pollen Mother Cells of the Vine.

By

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With 4 Text-figures.

(Received January 26, 1929)

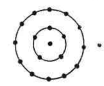
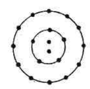
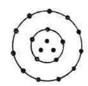
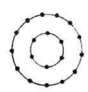
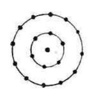
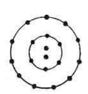
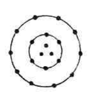
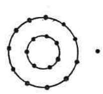
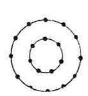
The haploid number of chromosomes was determined in the meiotic divisions in pollen mother cells[1]. It is 19 in all the cultivated varieties examined. They are 12 in number, of which six are varieties of *Vitis vinifera*, and called "Koshu" 甲州, "Koshu-sanjaku" 甲州三尺, "Yenshin" 圓心, "Ryugan" 龍眼, and Black Hamburgh, two are those of *Vitis labrusca*, called Adirondac and Campbell's Early, and one is *Vitis vulpina*, the remaining three being hybrid races called, Delaware, Lady Washington and Iona.

The chromosomes in the metaphase of the heterotype division of the pollen mother cells are of round shape in polar view, and of a dumb-bell shape in side view. They differ slightly in size and shape from one another, but there is generally no chromosome markedly distinguished it from the others, though in some of the nuclear plates a more or

[1] For fixing, various fixing fluids were used, of which BOUIN's fluid, material being placed in it for 24 hours after it had been treated with CARNOY's fluid (gl. acetic acid 1, chloroform 3, abs. alcohol 6 in volume) for 5 minutes, was found to be the most satisfactory. BOUIN's fluid applied for 3 hours after material had been treated with CARNOY's fluid for 5 minutes, and CARNOY's fluid applied for 24 hours also gave pretty good results. For staining, HEIDENHAIN's iron haematoxylin was exclusively employed. Other karyological details that have been omitted here will be published in a separate paper together with results of further investigations.

TABLE I *a*.

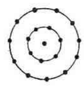
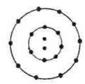
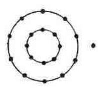
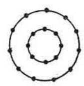
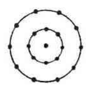
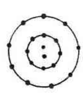
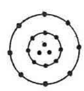
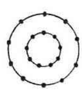
Cases where some of the chromosomes are found below or above the equatorial plate.

Type and formula[1]	Schematic representation of arrangement	Example	
		Camera drawing[2]	Name of variety
I (1 . 5 . 12+1)			" Koshu "
II (2 . 5 . 12)			Saltaniana
III (3 . 5 . 11)			Saltaniana
IV (0 . 6 . 13)			" Koshu "
V (1 . 6 . 12)			" Koshu "
VI (2 . 6 . 11)			Delaware
VII (3 . 6 . 10)			Delaware
VIII (0 . 7 . 11+1)			" Yenshin "
IX (0 . 7 . 12)			Delaware

1) The three figures mean the number of chromosomes occupying positions in the center, on the circumference of the middle ring, and on the circumference of the outer ring of arrangement respectively in the order written from left to right. When an additional figure is connected by the mark +, this figure means the number of chromosomes lying outside the outer ring of arrangement.

2) Solid circles represent chromosomes lying in the nuclear plate, those marked with a white cross those above, and hollow circles those below the plate.

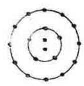
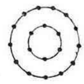
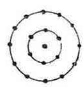
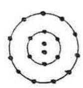
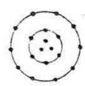
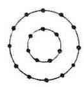
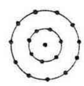
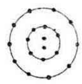
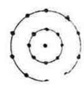
TABLE I *a.* (Continued)

Type and formula	Schematic representation of arrangement	Example	
		Camera drawing	Name of variety
X (1 . 7 . 11)			Saltaniana
XI (2 . 7 . 10)			Saltaniana
XII (0 . 8 . 10+1)			Delaware
XIII (0 . 8 . 11)			"Koshu"
XIV (1 . 8 . 10)			"Koshu"
XV (2 . 8 . 9)			Saltaniana
XVI (3 . 8 . 8)			"Yenshin"
XVII (0 . 9 . 10)			Saltaniana

less marked size difference may be recognizable among them. This, in part, seems to be due to fixation, and in part due to the fact that some of the chromosomes may take up a position somewhat inclined to the equatorial plane, so that the dumb-bell shaped chromosomes may appear to be larger than when they are disposed perpendicular to the plane. This slight difference in the size of the chromosomes led the writer to

TABLE I *b*.

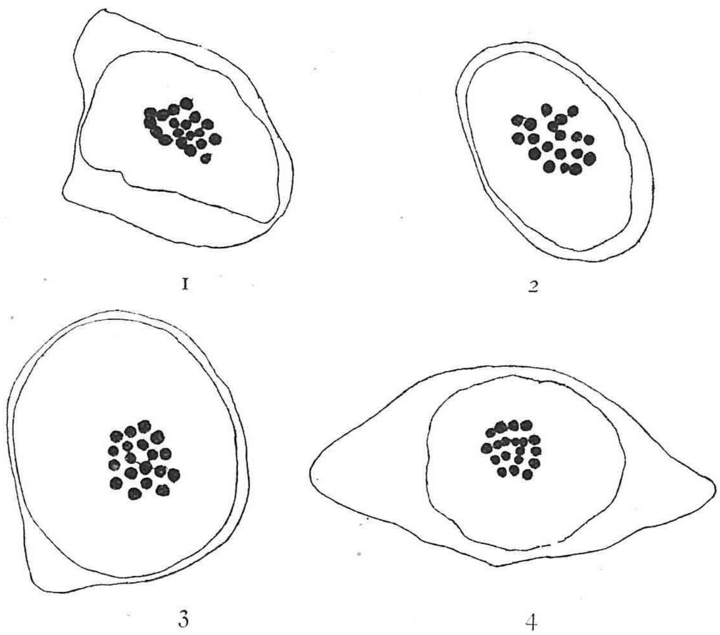
Cases where the chromosomes are arranged all in the equatorial plate.

Type and formula	Schematic representation of arrangement	Example	
		Camera drawing	Name of variety
II (2.5.12)			Black Hamburgh
IV (0.6.13)			" Koshu "
V (1.6.12)			Campbell's Early
VI (2.6.11)			Delaware
VII (3.6.10)			Campbell's Early
IX (0.7.12)			Saltaniana
X (1.7.11)			Delaware
XI (2.7.10)			Black Hamburgh
XIV (1.8.10)			" Koshu "

a closer investigation of chromosome arrangement to see whether its resemblance to the arrangement of MAYER's floating magnets, if there is any, is actually noticeable, as pointed out by DONCASTER[1] in such a case as *Vitis* where the chromosomes are of nearly the same size and shape. The arrangement was examined in stages about to form the nuclear plate in the heterotype division.

The chromosome arrangements so far examined can be grouped into 17 different types. These are shown in Table I, *a* and *b*.

While in cases where all the chromosomes are not arranged on one plane, some being below or above the others, we have all these types (Table I, *a*), in cases where the chromosomes are arranged all on one plane we have only 10 of these types (Table I, *b*). This fact



Figs. 1–4. Pollen mother cells showing parallel transfiguration in the distribution area of chromosomes and the protoplast due to the latter's contraction caused by fixation. 1. "Koshu." 2. Black Hamburgh. 3. Delaware. 4. Saltaniana.

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1) DONCASTER, L. (1924), An Introduction to the Study of Cytology, London.

TABLE II *a*.

Type of arrangement / Name of variety	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	Total
"Koshu"	1	1	1	3	4	8	0	0	0	1	8	0	3	7	2	0	0	39
Saltaniana	2	1	2	2	7	5	1	1	8	1	9	0	1	2	2	0	1	45
Delaware	0	0	0	0	2	3	1	0	3	0	3	1	0	0	1	0	0	14
Campbell's Early	0	0	1	1	3	5	0	0	2	0	1	0	0	2	0	0	0	15
Lady Washington	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	3
"Ryugan"	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Iona	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
"Yenshin"	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	0	3
Black Hamburgh	0	1	0	0	0	1	0	0	2	0	3	0	1	0	0	0	0	8
Adirondac	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
"Koshu-sanjaku"	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2
vulpina	0	0	0	0	0	0	0	0	1	1	2	0	0	0	0	0	0	4
Total	3	3	4	7	16	23	2	2	17	5	29	1	5	12	5	2	1	137
%	2.18	2.18	2.91	5.10	11.67	16.78	1.45	1.45	12.40	3.64	21.16	0.72	3.64	8.75	3.64	1.45	0.72	99.84

TABLE II *b*.

Type of arr. / Name of variety	II	IV	V	VI	VII	IX	X	XI	XIV	Total
"Koshu"	0	1	1	2	0	3	5	1	1	14
Saltaniana	0	0	0	1	0	3	16	0	1	21
Delaware	0	0	0	2	0	0	10	0	0	12
Campbell's Early	0	0	1	0	1	0	4	0	0	6
"Ryugan"	0	0	0	0	0	0	1	0	0	1
Black Hamburgh	1	0	0	0	0	0	3	1	0	5
"Koshu-sanjaku"	0	0	0	0	0	1	3	0	0	4
Total	1	1	2	5	1	7	42	2	2	63
%	1.58	1.58	3.17	7.93	1.58	11.11	66.66	3.17	3.17	99.95

shows, that when the chromosomes take their final position in the equatorial plate, the number of these types of arrangement is greatly reduced.

While in some of the cases observed the arrangements are similar to the schematic representations, in others they appear to be quite different from the schemas, but here it is to be understood that such cases are those which have been deformed out of shape by fixation. In Figs. 1–4, it will be seen from the corresponding deformed shapes of the protoplast that such is actually the case.

The numbers of cases of the different types observed in different varieties are tabulated in Table II, *a* and *b*. In *b* only those cases are selected where all the chromosomes are arranged practically on one plane, and in *a* those cases where some of the chromosomes are found to a greater or less extent above or below the nuclear plate.

From Table II *b*, we see that Type X (1. 7. 11) which resembles the stable form of grouping of 19 floating magnets[1] is of the most

[1] See MIZUNO (1916), "Theory of the Atom," Part II (in Japanese).

frequent occurrence. If we sum up the frequency values given in Table II, *b* of all the types having 7 chromosomes in the middle ring of arrangement (–. 7. –), we have 80.94, and for types having 11 chromosomes in the outer ring (–. –. 11), 74.59, and for those having one chromosome in the center (1. –. –), 73.00. These total values of the frequencies show that there is a stronger tendency for the middle ring to have as many chromosomes as in the stable arrangement form of floating magnets than the outer ring and the center. Now, if we add the frequency values of types having the same number of chromosomes in the middle ring all together, we have:

1.58...........	for the types having	5	chromosomes	in the middle ring	(–. 5. –)
14.26...........	"	6	"	"	(–. 6. –)
80.94...........	"	7	"	"	(–. 7. –)
3.17...........	"	8	"	"	(–. 8. –)

The results show that the strongest tendency is for 7 chromosomes to appear in the middle ring, and that the tendency towards 6, 8, or 5 is weaker and weaker in the order named. For the corresponding values from the data given in Table II, *a*, we have:

7.27...........	for the types having	5	chromosomes	in the middle ring	(–. 5. –)
35.00...........	"	6	"	"	(–. 6. –)
38.65...........	"	7	"	"	(–. 7. –)
18.20...........	"	8	"	"	(–. 8. –)
0.72...........	"	9	"	"	(–. 9. –)

From these results we see that there is nearly the same series of tendencies in respect to the number of chromosomes occupying position in the middle ring as we have just seen in the results obtained from Table II, *b*. The slope of curves obtainable from these two parallel results show that the arrangement configurations grouped together in Table II, *a* are those in transitory stages to those grouped in Table II, *b*. In this connection it is also an interesting fact that in the latter case the number of types of arrangement is greatly reduced.

SUMMARY.

1) In pollen mother cells of *Vitis vulpina*, six cultivated varieties of *V. vinifera*, two cultivated varieties of *V. labrusca*, and three hybrid races, the haploid number of chromosomes was found to be 19.

2) The chromosomes in the heterotype metaphase are nearly of the same size and shape, being round in polar view and dumb-bell shaped in side view.

3) When the chromosomes are arranged all in the nuclear plate, the resemblance of the arrangement to that of Mayer's floating magnets was recognizable in 66.66% of the cases observed.

4) The tendency to have the same number of chromosomes as that of the floating magnets in their stable form of arrangement was found to be the strongest in the middle ring of the chromosome arrangement.

5) The frequency curve obtainable from cases where all the chromosomes are arranged in the nuclear plate by grouping together the frequency values of all the types of arrangement having the same number of chromosomes in the middle ring, is similar to, but steeper than the corresponding curve from the data obtained in cases where all the chromosomes are not arranged strictly on one plane, some being below or above the plane.

In conclusion, I wish to express my sincere thanks to Prof. Kuwada, under whose direction the present investigation was carried out. My thanks are also due to Prof. Namikawa of the Agricultural Department of our university, to Mr. K. Nagai and Mr. R. Inoue of the Okitsu Agricultural Experiment Station, and to Mr. N. Kasuga, Director of the Nara Agricultural Experiment Station, who kindly placed the material at my disposal.