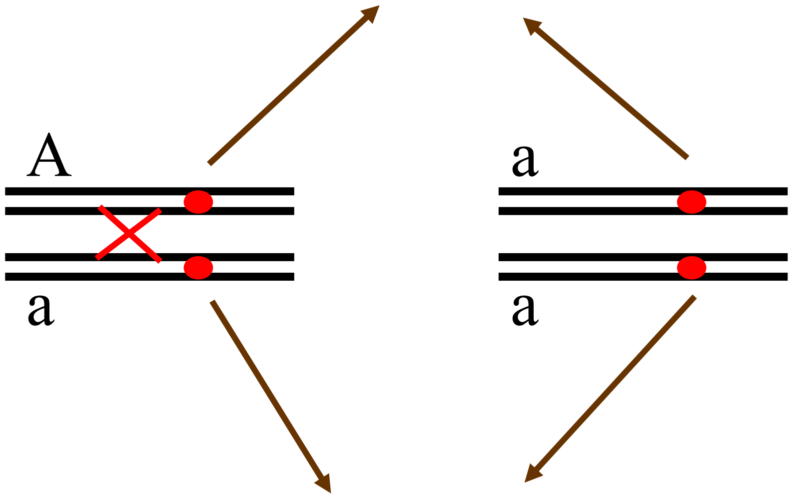
Chromosome segregation in autopolyploids

Random chromosome assortment :

Quadrivalents are never formed
Locus in question far enough from the centromere to allow chiasma formation
Sister chromatids at this locus can never end in the same gamete



- ✓ The centromeres will always pass to the same pole at anaphase I and separate at anaphase II
- ✓ The dominant alleles will not appear in the same gamete

Chromosome segregation in autopolyploids

Random chromosome assortment (Quadrivalents are <u>never</u> formed):

Gametic ratio: 1Aa:1aa

Zygotic expectation from selfing Aaaa

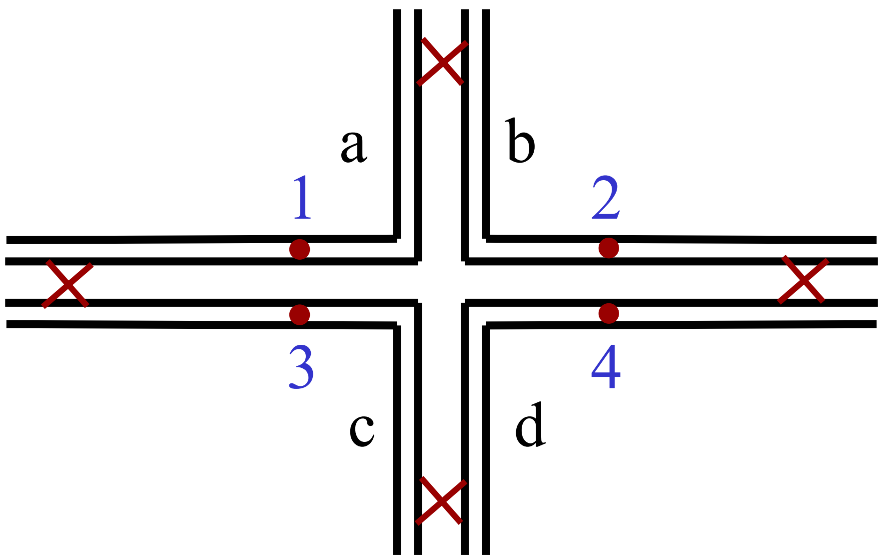
♀ \ ♂	Aa	aa
Aa	AAaa	Aaaa
aa	Aaaa	aaaa

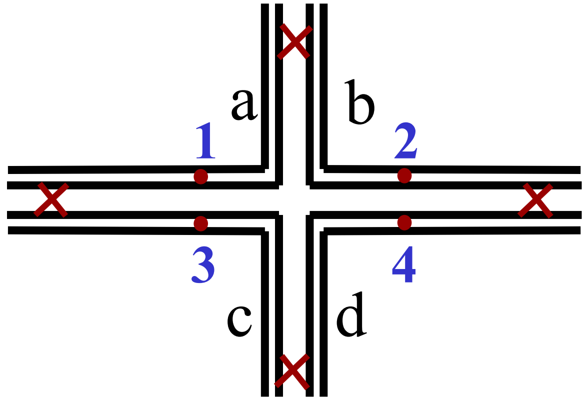
3 A _ _ _ : 1 aaaa

Chromosome segregation in autopolyploids

Random chromosome segregation:

Quadrivalents are formed
No chiasma formation between the locus in question and the centromere
Sister chromatids never end in the same gamete





Anaphase I		Anaphase II		Gametes
1 + 2	aa + bb	a + b	a + b	ab + ab
3 + 4	cc + dd	c + d	c + d	cd + cd
1 + 3	aa + cc	a + c	a + c	ac + ac
2 + 4	bb + dd	b + d	b + d	bd + bd
1 + 4	aa + dd	a + d	a + d	ad + ad
2 + 3	bb + cc	b + c	b + c	bc + bc

Chromosome segregation in autopolyploids

Random chromosome segregation:

Gametic frequency:

2 ab + 2 cd + 2 ac + 2 bd + 2 ad + 2 bc

or

ab + cd + ac + bd + ad + bc

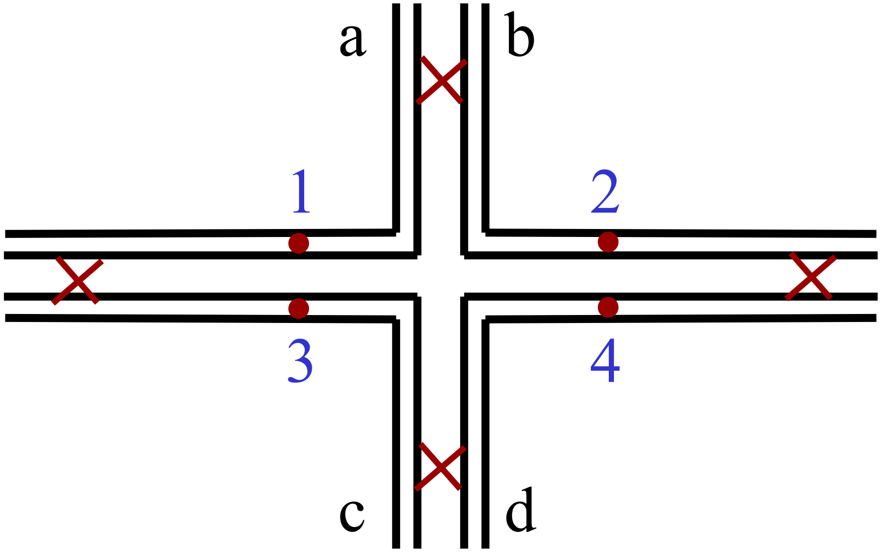
Chromosome segregation in autopolyploids

Random chromatid assortment:

Quadrivalents are formed

Locus in question far enough from the centromere to allow chiasma formation

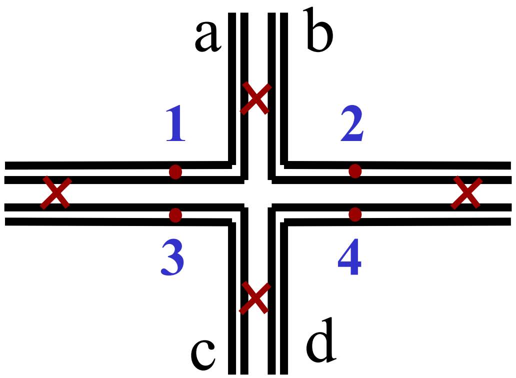
Sister chromatids never end in the same gamete



Anaphase I		Anaphase II			Gametes
1 + 2	ab + ab	a + a	↔	b + b	aa* + bb*
			or		
		a + b	↔	a + b	ab + ab
↕	↕				
3 + 4	cd + cd	c + c	↔	d + d	cc* + dd*
			or		
		c + d	↔	c + d	cd + cd
1 + 3	ab + cd	a + c	↔	b + d	ac + bd
			or		
		a + d	↔	b + c	ad + bc
↕	↕				
2 + 4	ab + cd	a + c	↔	b + d	ac + bd
			or		
		a + d	↔	b + c	ad + bc
1 + 4	ab + cd	a + c	↔	b + d	ac + bd
			or		
		a + d	↔	b + c	ad + bc
↕	↕				
2 + 3	ab + cd	a + c	↔	b + d	ac + bd
			or		
		a + d	↔	b + c	ad + bc

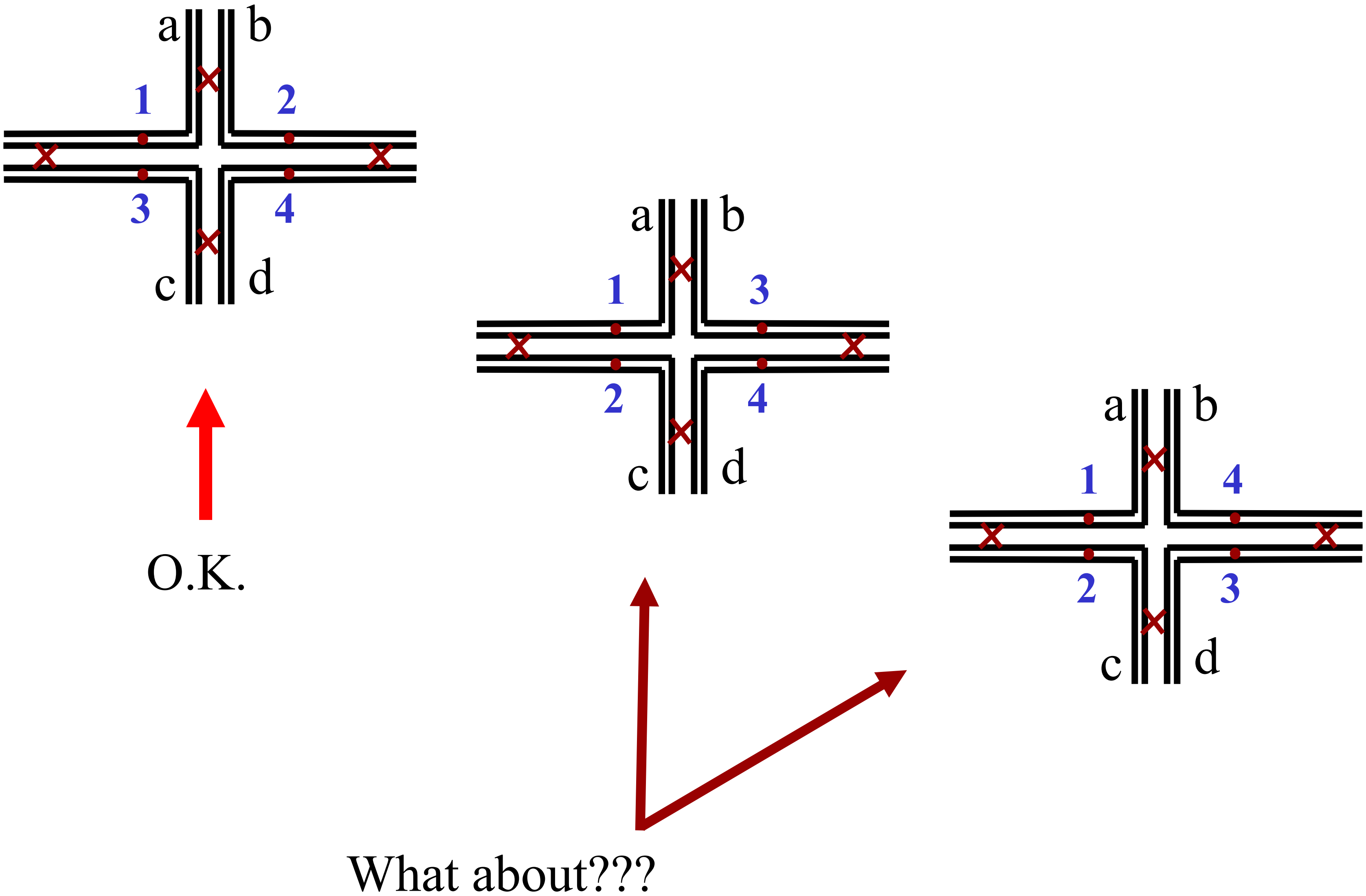
Chromosome segregation in autopolyploids

Random chromatid assortment:



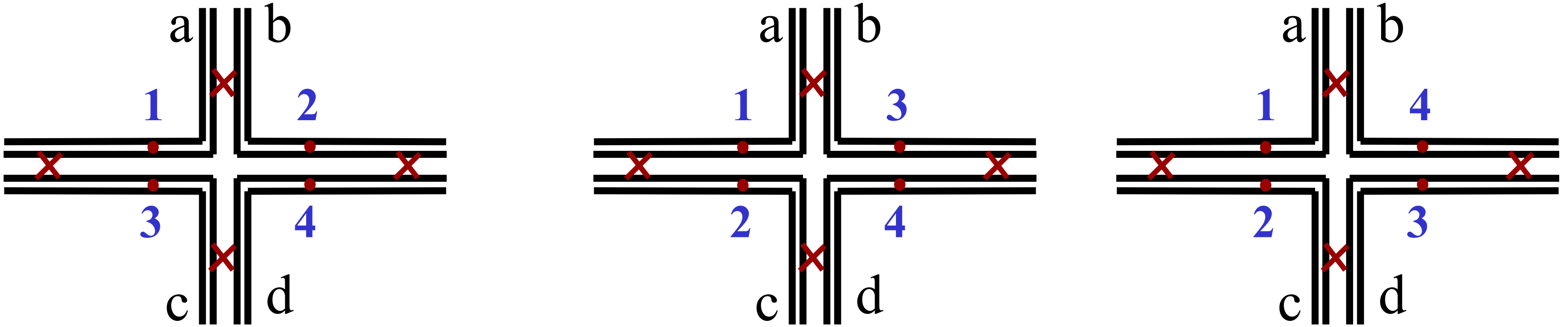
Gametic frequency:

aa* + bb* + cc* + dd* + 2ab + 2cd + 4ac + 4bd + 4 ad + 4bc


a
b
1
2
3
4
c
d
a
b
1
3
2
4
c
d
a
b
1
4
2
3
c
d
O.K.
What about???

Chromosome segregation in autopolyploids

Random chromatid assortment:



Gametic frequency:

3aa* + 3bb* + 3cc* + 3dd* + 10ab + 10cd + 10ac + 10bd + 10ad + 10bc

Double reduction gametes are 12/72 or 1/6

Highest frequency of double reduction gametes also called Maximum equational segregation

Gametic types and frequencies expected from chromosome and maximum equational segregation in tetraploids or tetrasomics heterozygous at a single locus

Genotype	Chromosome segregation	% rr	Maximum Equational Segregation	% rr
AAAa	AA + Aa	0	13 AA + 10 Aa + aa	4.2
AAaa	AA + 4 Aa + aa	16.7	2 AA+ 5 Aa + 2 aa	22.2
Aaaa	Aa + aa	50.0	AA + 10 Aa + 13 aa	54.2

The differences in the frequency of aa for chromosome and maximum equational segregation are not large:

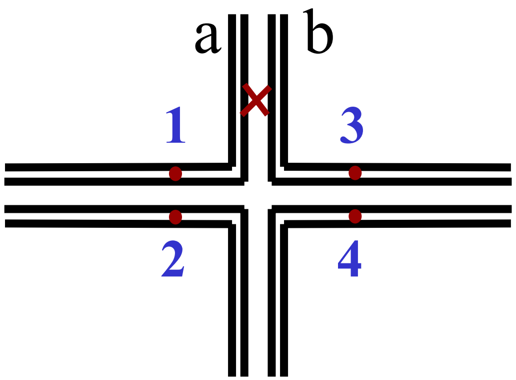
Triplex and simplex	4.2%
Duplex	5.5%

Maximum equational segregation

✓ First division is reductional for the centromere

Mather proposed an index of separation to predic the theoratical extremes dependent on the parameters *a* and *e*:

a = frequency with which equationally separating chromosomes pass to the same telophase nucleus at the end of the first meiotic division.
0 - 1/3, maximum *a* is 1/3 if the quadrivalent is formed



Centromere disjunction

1 + 2
1 + 4
1 + 3*

* Only the 1 + 3 will allow equational separation *a* max = 1/3

e = the mean frequency of equational separation.
0 - 1, with no crossover *e*=0 and with 1 crossover between the locus and the centromere, *e* can reach a maximum value of 1

The maximum value of equational separation = 1/3 x 1 = 1/3

Maximum equational segregation

At maximum only 1/2 of the gametes are double reductional for the locus because of random segregation of the chromatids at the second division.

The maximum frequency of double reduction = 1/2 x 1/3 = 1/6

Double reduction gametes are 12/72 or 1/6

Highest frequency of double reduction gametes also called Maximum equational segregation

1/2 x 1/3 = 1/6

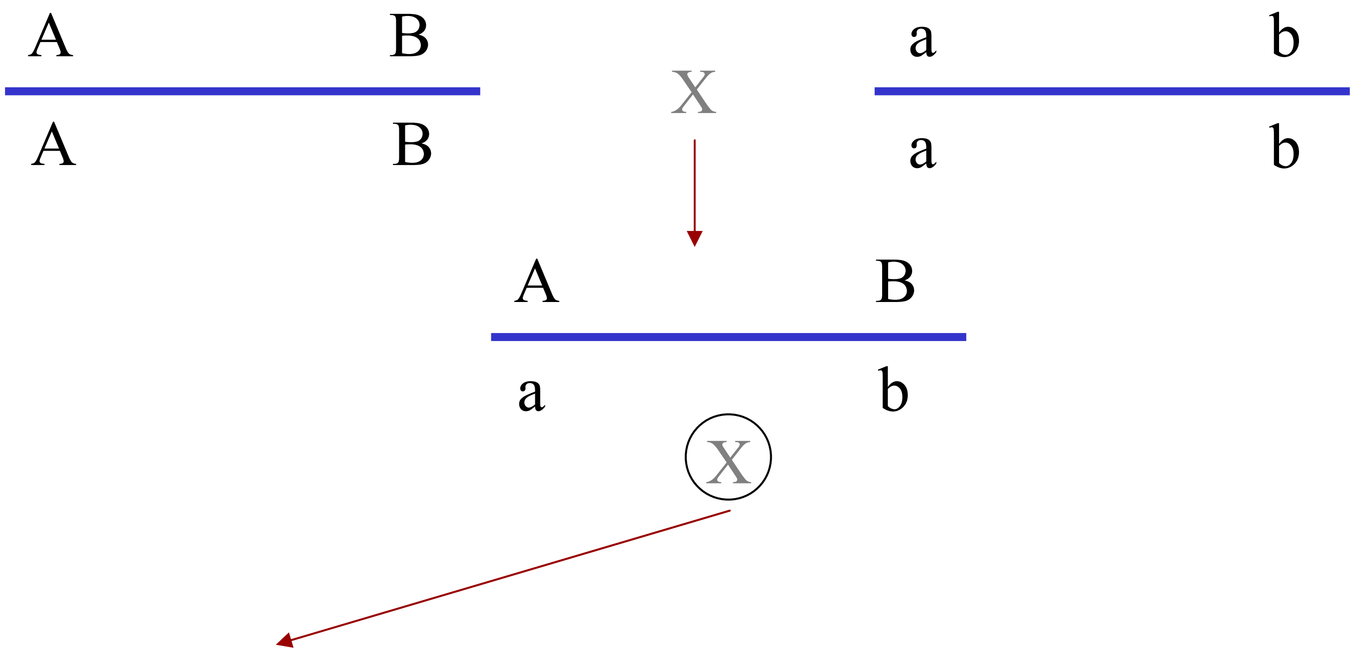
Linkage in autopolyploids

- ✓ The frequency of double reduction is a relative measure of the distance between the gene and the centromere.

- ✓ If two genes are linkes, and double reduction for A is observed, but not for B, the centromere is between them.

Linkage in autopolyploids

Diploids:



AB
ab
} Parental

Ab
aB
} Recombinant

%r = recombinant/total x100

Linkage in autopolyploids

Diploids:

Diploids produce only two types of heterozygots:

$$\frac{A \quad B}{a \quad b} \qquad\qquad \frac{A \quad b}{a \quad B}$$

Coupling Repulsion

The frequencies of the different kinds of gametes can be determined in the first backcross or testcross

Linkage in autopolyploids

In an autoteraploid heterozygous at two loci, there are 3 possible heterozygotes at each locus:

Aaaa, AAaa, AAAa

Bbbb, BBbb, BBBb

Total of 9 possible combinations

Linkage in autopolyploids

Heterozygous types from tetraploid heterozygous at two loci

For A vs. a \ For B vs. b	BBBb	BBbb	Bbbb
AAAa	A^3aB^3b	$A^3aB^2b^2$	A^3aBb^3
AAaa	$A^2a^2B^3b$	$A^2a^3B^2b^2$	$A^2a^2Bb^3$
Aaaa	Aa^3B^3b	$Aa^3B^2b^2$	Aa^3Bb^3

Linkage in autopolyploids

- For each of the 9 combinations, the genes may be arranged on the four members of the tetrasome in more than one way

- The $A^2a^2B^2b^2$ combination may occur in three different genotypic arrangements on the chromosomes:

A	B		A	B		A	b
A	B	or	a	b	or	A	b
a	b		A	b		a	B
a	b		a	B		a	B

Linkage in autopolyploids

- For each of the 9 combinations, the genes may be arranged on the four members of the tetrasome in more than one way
- The $A^2a^2B^2b^2$ combination may occur in three different genotypic arrangements on the chromosomes
- Each of the other 8 combinations can be arranged in two different ways on the chromosome, making a total of 19 possible chromosomal genotypes in all

Example: Aa^3 Bb^3

Linkage in autopolyploids

- Fisher (see Burnham) used a double entry table for denoting the various genetic constitutions of the four chromosomes in a quadrivalent.

- Example: Genotype AB Ab aB ab is represented as

Each of the four positions corresponds to that in the double entry table:

	B	b
A	AB	Ab
a	aB	ab

Linkage in autopolyploids

Isomorphic sets

An AB $(ab)^3$ genotype is denoted:

	B	b
A	AB	.
a	.	$(ab)^3$

The pairing of AB with any of the other three of the tetrasomes in this genotype will produce recognizable crossover products.

Linkage in autopolyploids

Isomorphic sets

The following genotypes will produce the same results:

aB $(Ab)^3$ $(aB)^3$ Ab $(AB)^3$ ab

Linkage in autopolyploids

Isomorphic sets

The following genotypes will produce the same results:

$aB\ (Ab)^3$	$(aB)^3\ Ab$	$(AB)^3\ ab$
. 3 / 1 .	. 1 / 3 .	3 . / . 1

	B	b
A	.	$(Ab)^3$
a	aB	.

	B	b
A	.	Ab
a	$(aB)^3$	.

	B	b
A	$(AB)^3$	.
a	.	ab

All positions of 3-1 in the square

Linkage in autopolyploids

Isomorphic sets

The following genotypes will produce the same results:

$AB\,(ab)^3$		$aB\,(Ab)^3$		$(aB)^3\,Ab$		$(AB)^3\,ab$	
1	.	.	3	.	1	3	.
.	3	1	.	3	.	.	1

All positions of 3-1 in the square

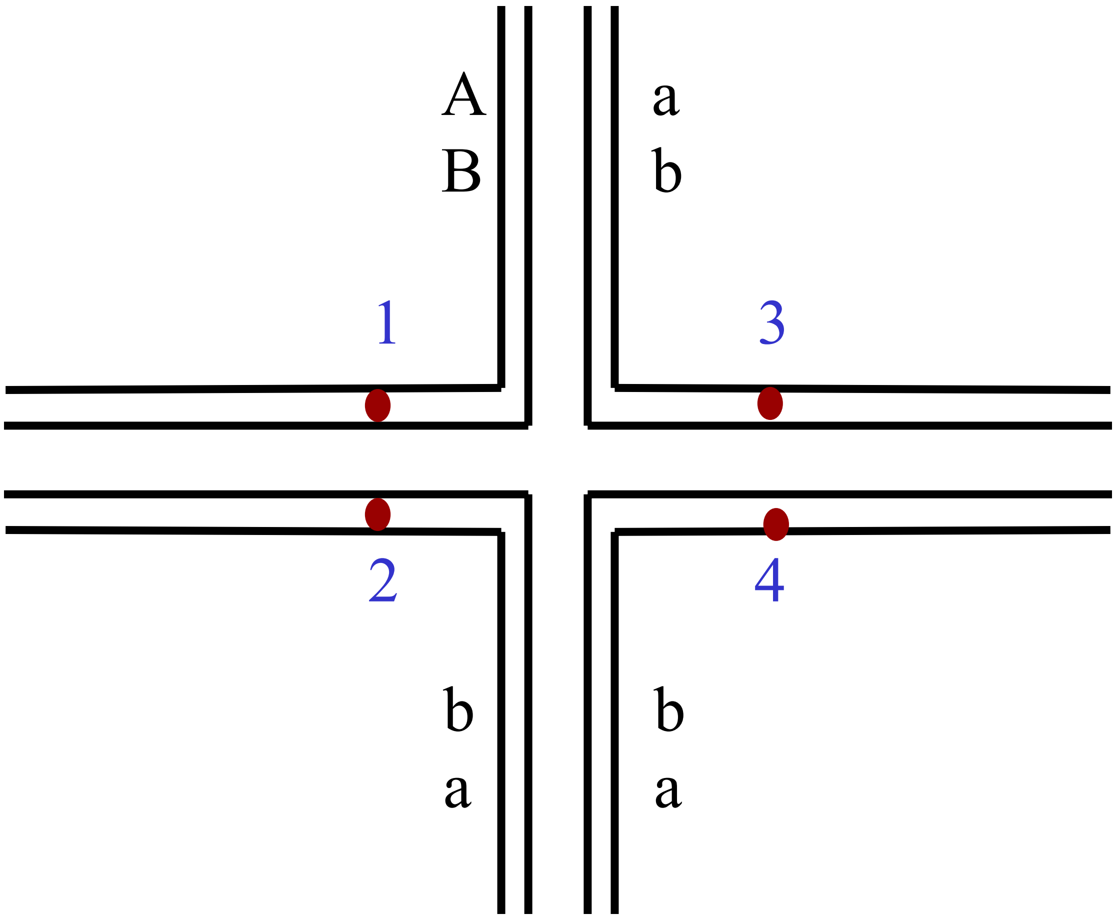
These four genotypes represent an isomorphic set

Linkage in autopolyploids

- All members of the isomorphic set furnish equivalent information in the sense that they yield gametic series with the same frequencies.

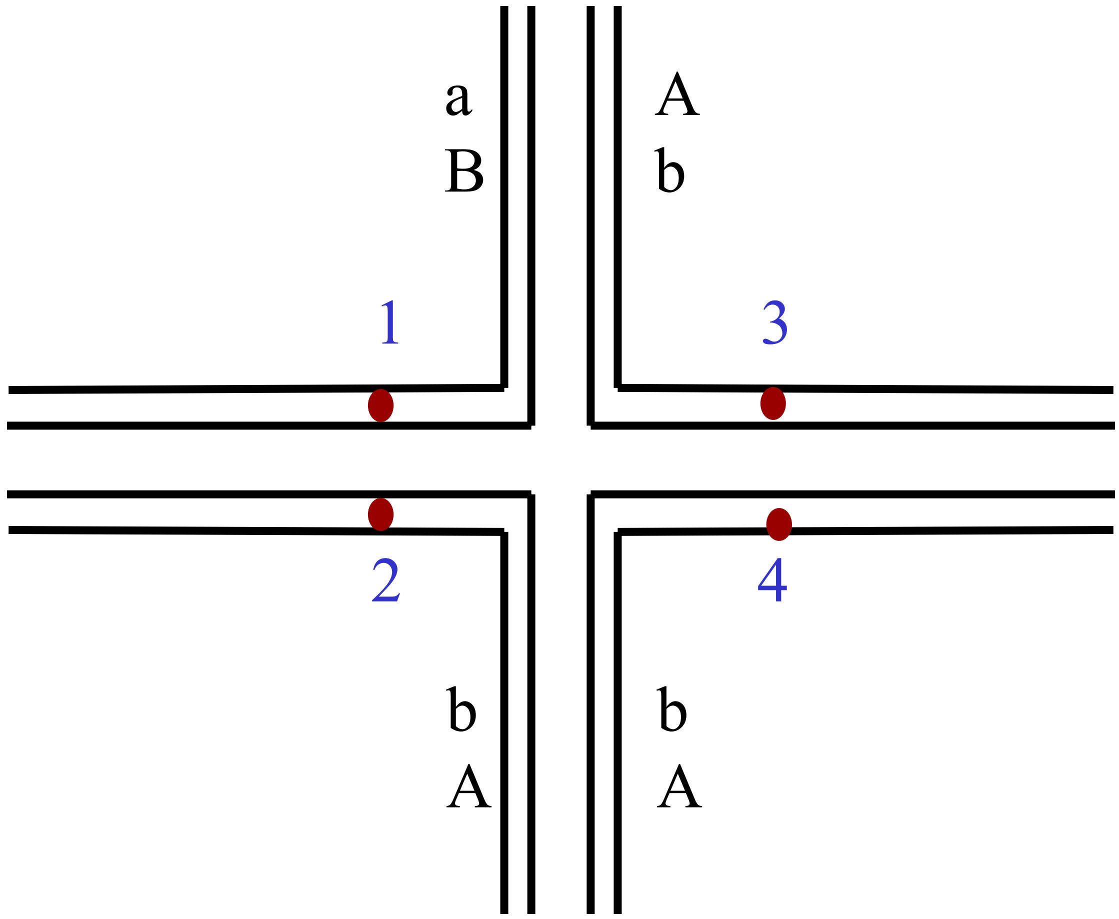
- The analysis of more than one member of a set adds no additional information. Those belonging to different isomorphic sets may furnish supplemental information on linkage.

AB $(ab)^3$



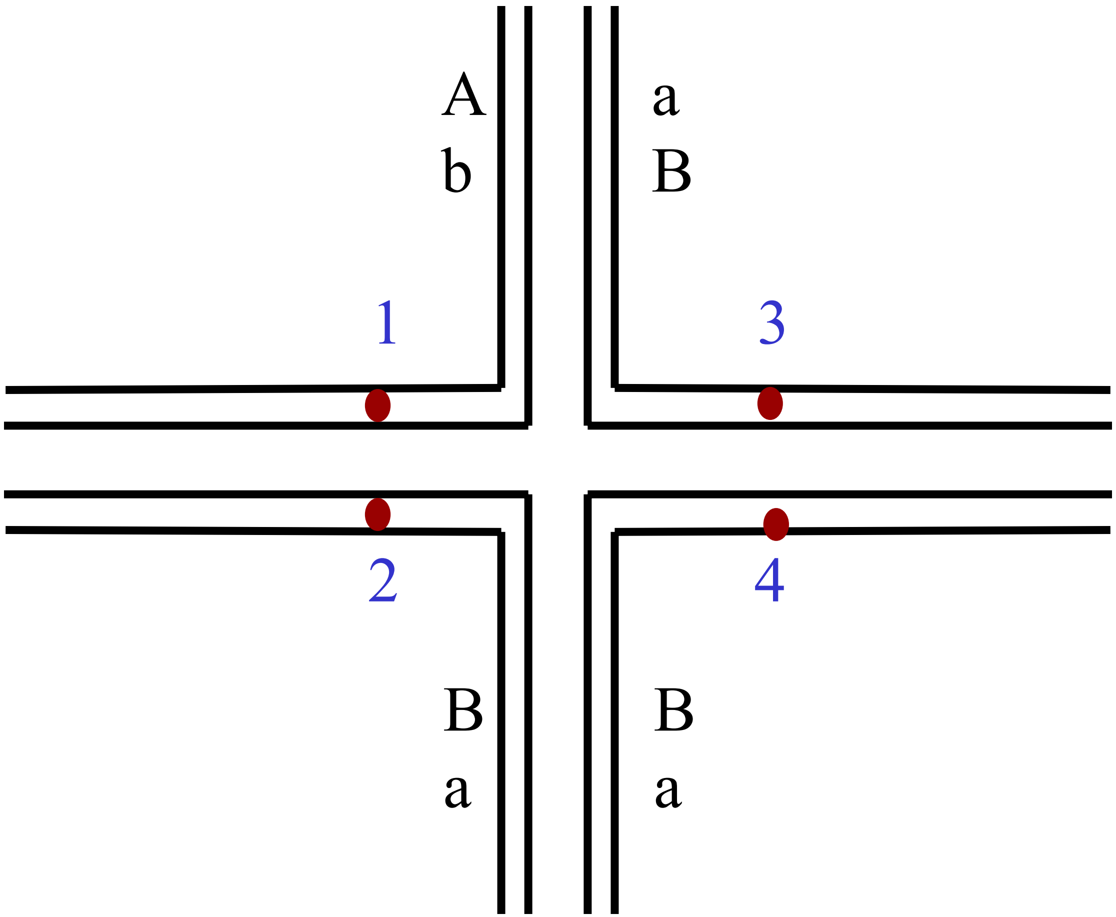
1 + 2
1 + 3
1 + 4
2 + 3
2 + 4
3 + 4

aB $(Ab)^3$



1 + 2
1 + 3
1 + 4
2 + 3
2 + 4
3 + 4

$(aB)^3$ Ab



1 + 2

1 + 3

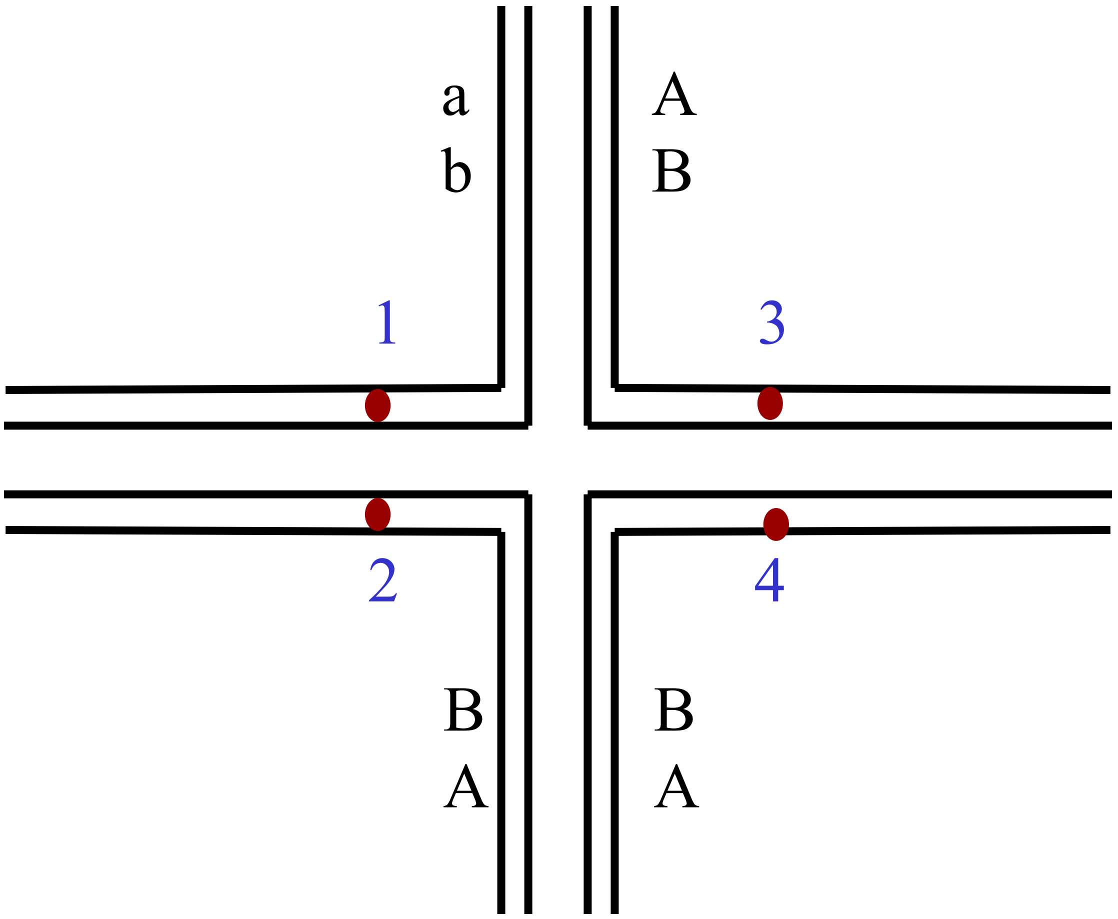
1 + 4

2 + 3

2 + 4

3 + 4

$(AB)^3$ ab



1 + 2

1 + 3

1 + 4

2 + 3

2 + 4

3 + 4