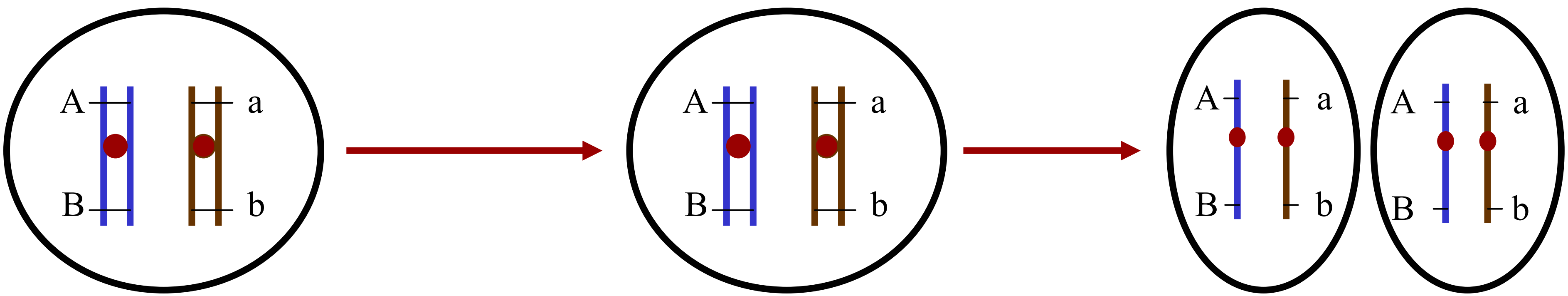
First-Division Restitution (FDR)

Failure of spindle formation results in nuclear membrane reforming around the chromosomes without movement to opposite poles

Normal disjunction at second division of meiosis



Meiotic prophase

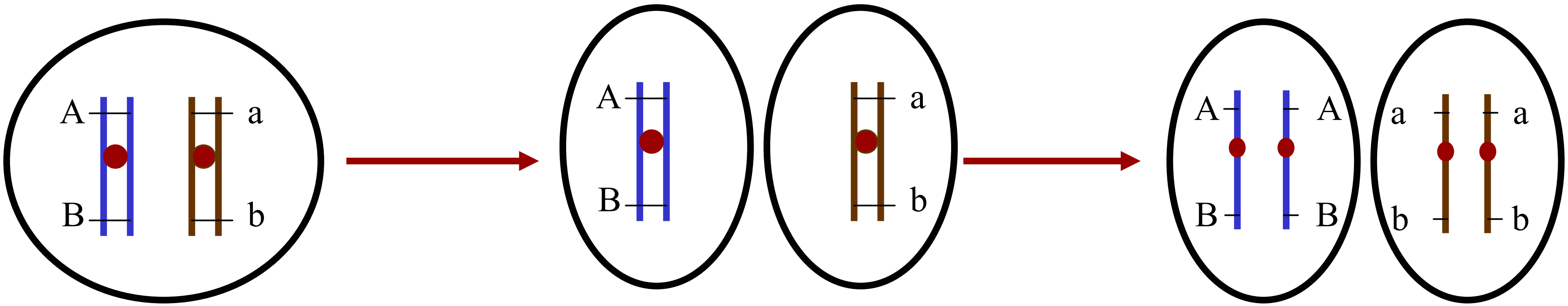
Product of FDR
Telophase I

Both gametes are AaBb

Second-Division Restitution (SDR)

Normal separation of homologous chromosomes

Separation of sister chromatids occurs during meiosis II, but no cell plate is formed at the end



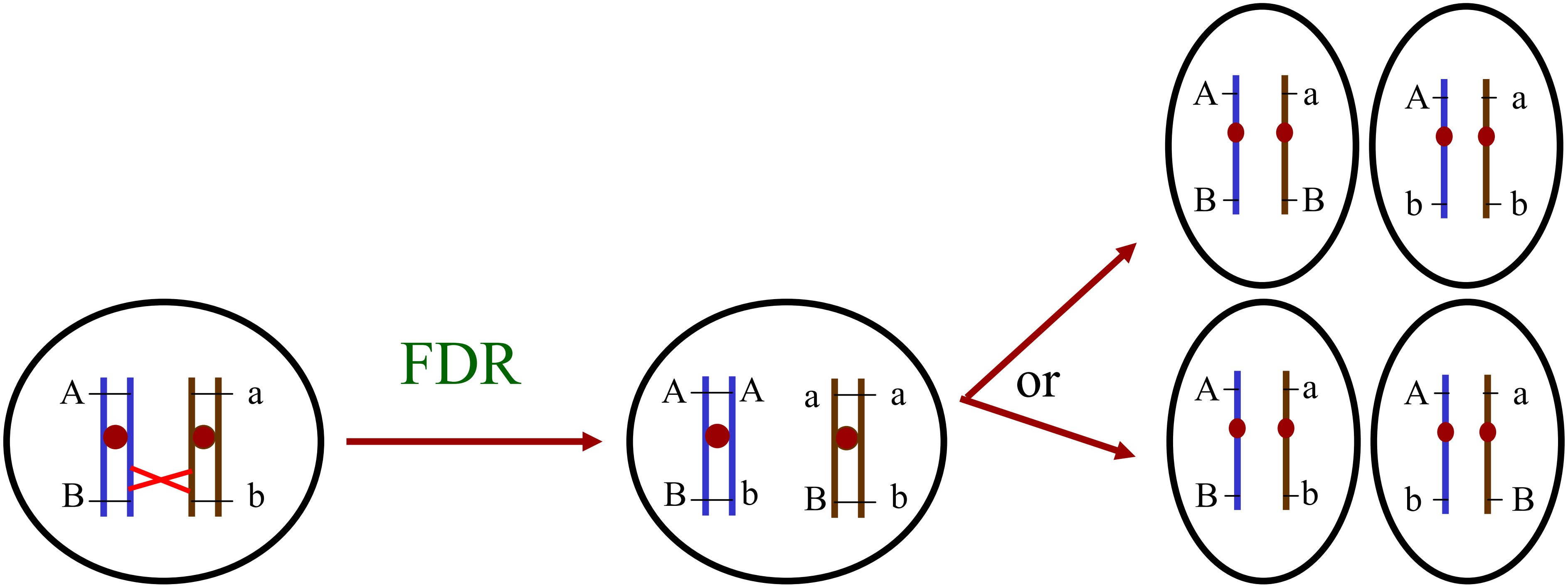
Meiotic prophase

Telophase I

Products of SDR

Gametes recovered are 1AABB: 1 aabb

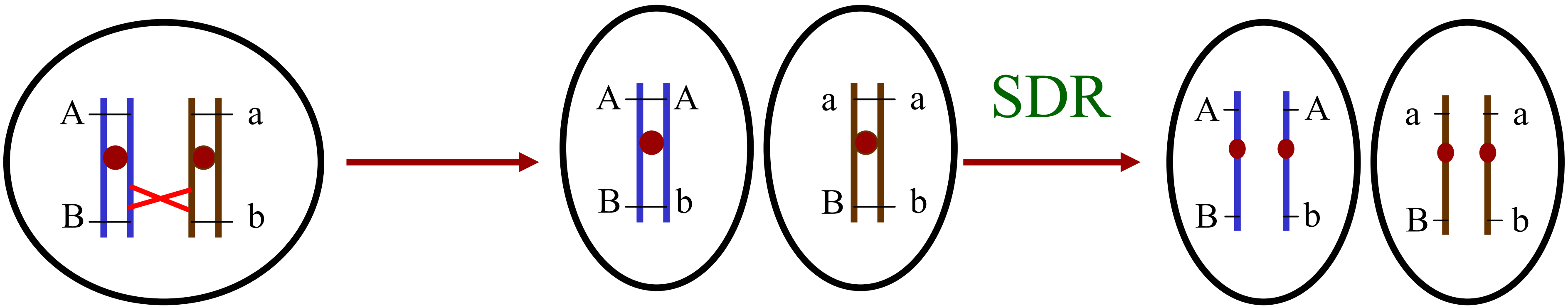
Results of FDR after a single crossover between the centromere and the *B/b* locus



100% Aa

50% Bb
25% BB
25% bb

Results of SDR after a single crossover between the centromere and the *B/b* locus



50% AA

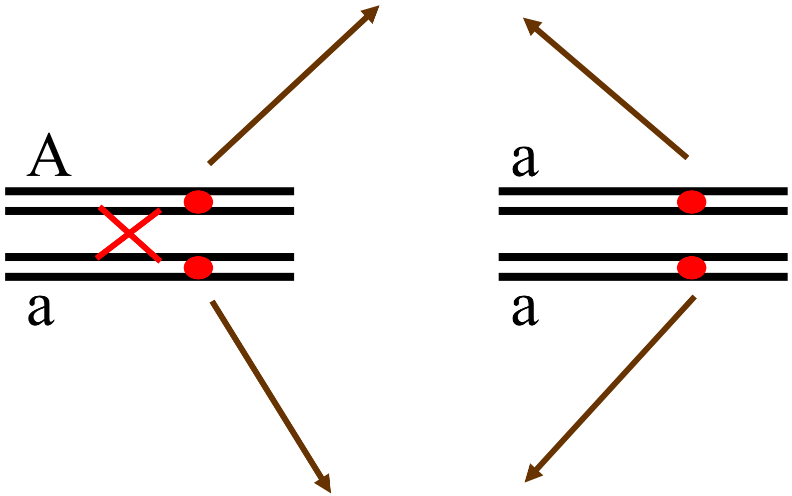
50% aa

100% Bb

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

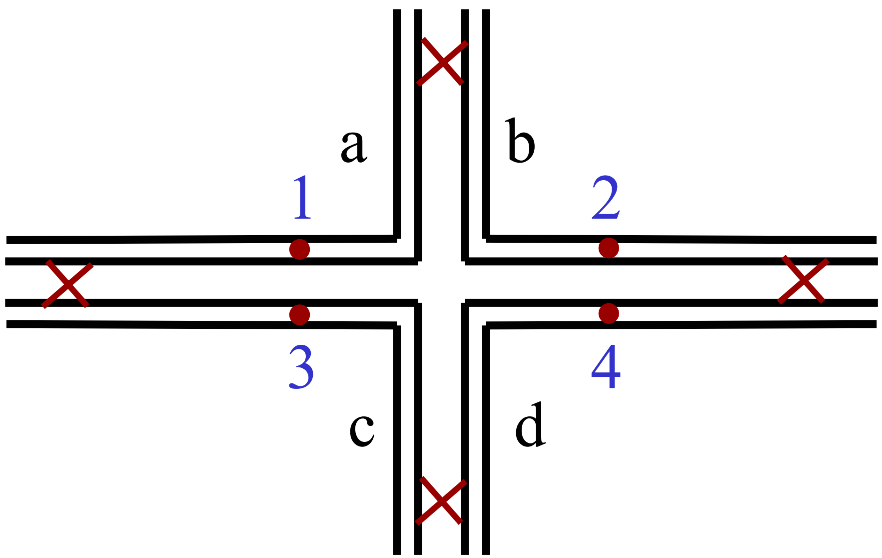
♀ \ ♂	Aa	aa
Aa	AAaa	Aaaa
aa	Aaaa	aaaa

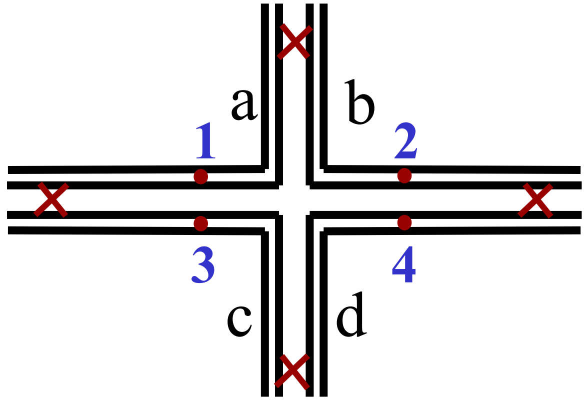
3 A _ _ _ : 1 aaaa

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

Example: AAaa (=abcd)

Gametes are:

ab = AA

cd = aa

ac = Aa

bd = Aa

ad = Aa

bc = Aa

→ or 1 AA : 1 aa : 4 Aa

Chromosome segregation in autopolyploids

Random chromosome segregation:

Gametic ratios are: 1 AA : 1 aa : 4 Aa

	AA	aa	4 Aa
AA	AAAA	AAaa	4 AAAa
aa	AAaa	aaaa	4 Aaaa
4 Aa	4 AAAa	4 Aaaa	16 AAaa

35 A_ _ _ : 1 aaaa

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

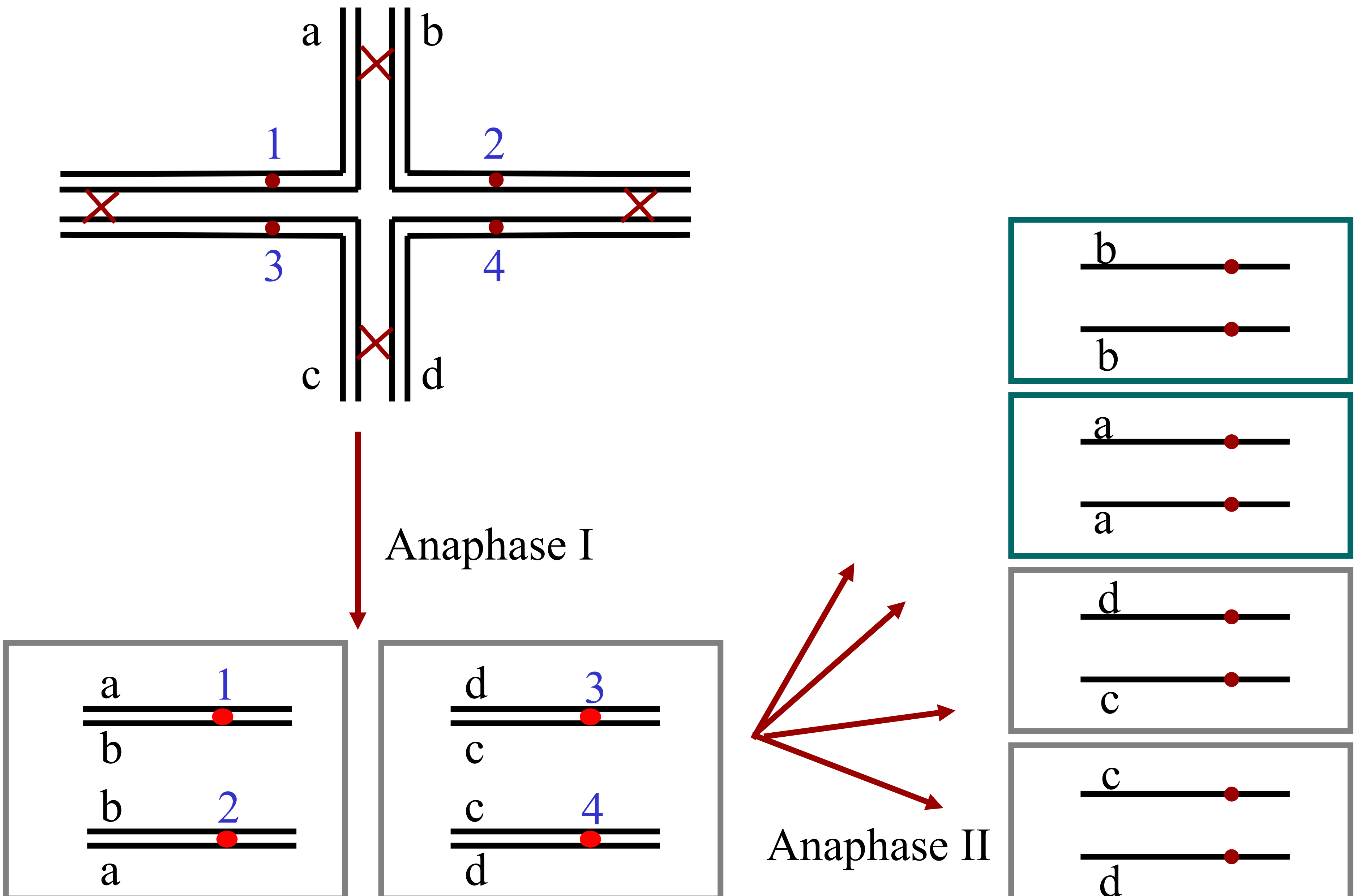
- ✓ When quadrivalent formation is complete and 50% crossing over occurs between the centromere and the locus, the partition of chromatids to gametes will be random.
- ✓ Requirements for double reduction (requires that after crossing over between the centromere and gene marker in adjacent chromosomes, these chromosomes go to the same pole at anaphase I):

Chromosome segregation in autopolyploids

Random chromatid assortment (Quadrivalents are formed):

- ✓ Requirements for double reduction (requires that after crossing over between the centromere and gene marker in adjacent chromosomes, these chromosomes go to the same pole at anaphase I):

1. Multivalent formation
2. Crossover between the gene and the centromere
3. Two pairs of chromatids resulting from crossing over must pass to the same pole at anaphase I
4. Random separation of chromatids at anaphase II



a
b
1
2
3
4
c
d
Anaphase I
a
1
b
b
2
a
d
3
c
c
4
d
Anaphase II
b
b
a
a
d
c
c
d

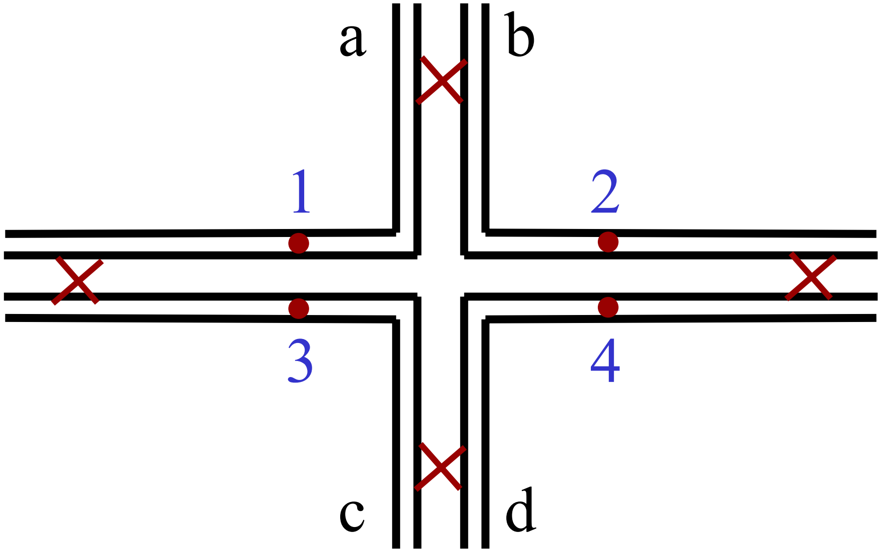
Chromosome segregation in autopolyploids

Random chromatid assortment:

Quadrivalents are formed

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

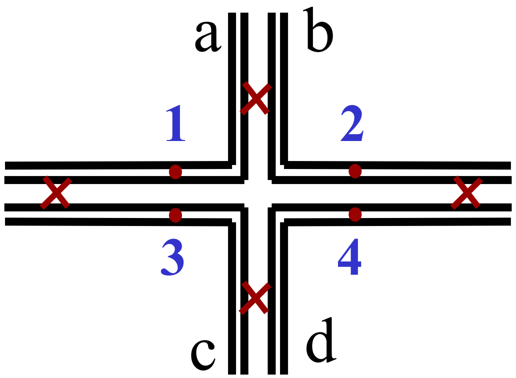
Sister chromatids never end in the same gamete



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

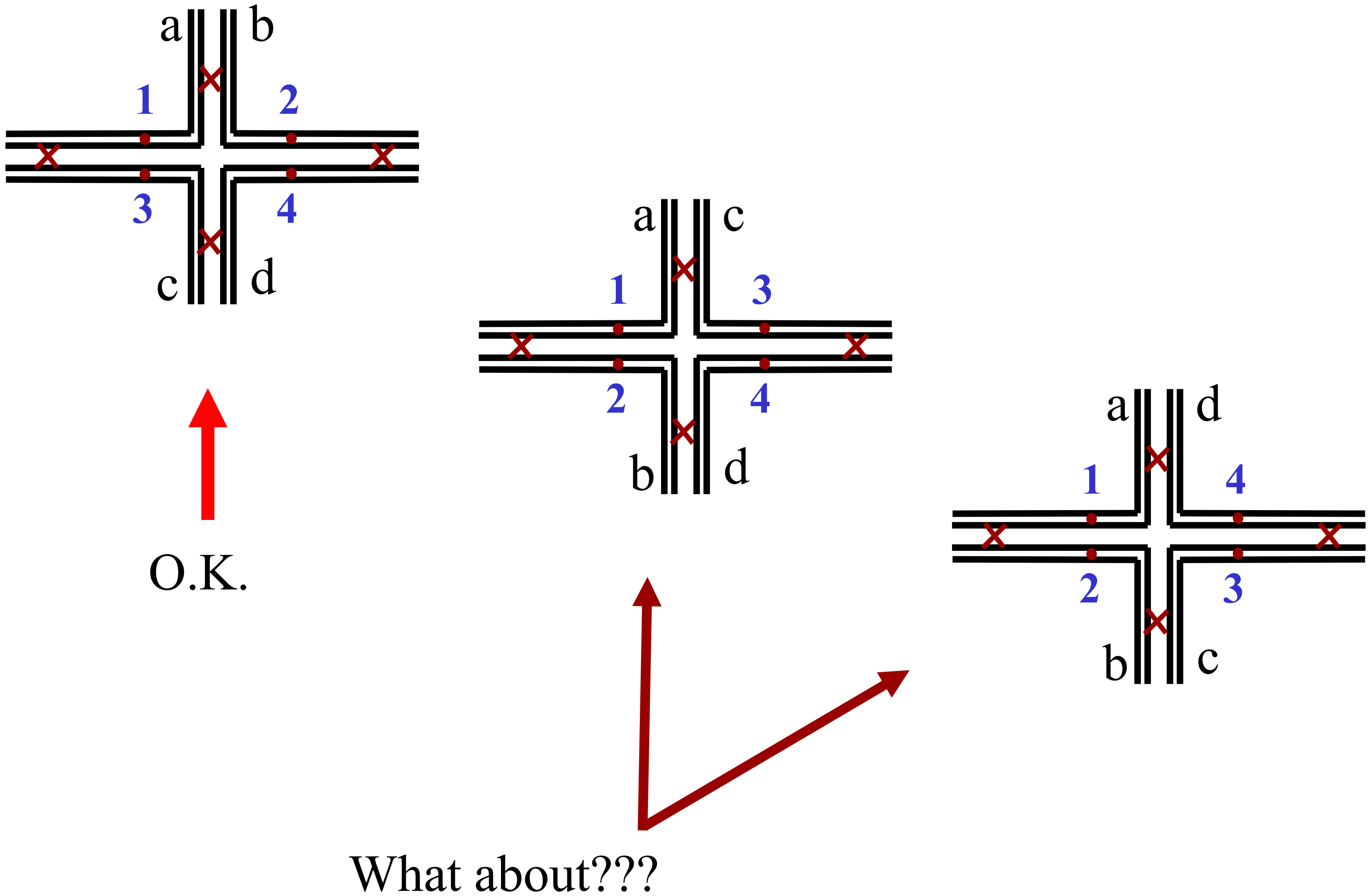
Chromosome segregation in autopolyploids

Random chromatid assortment:



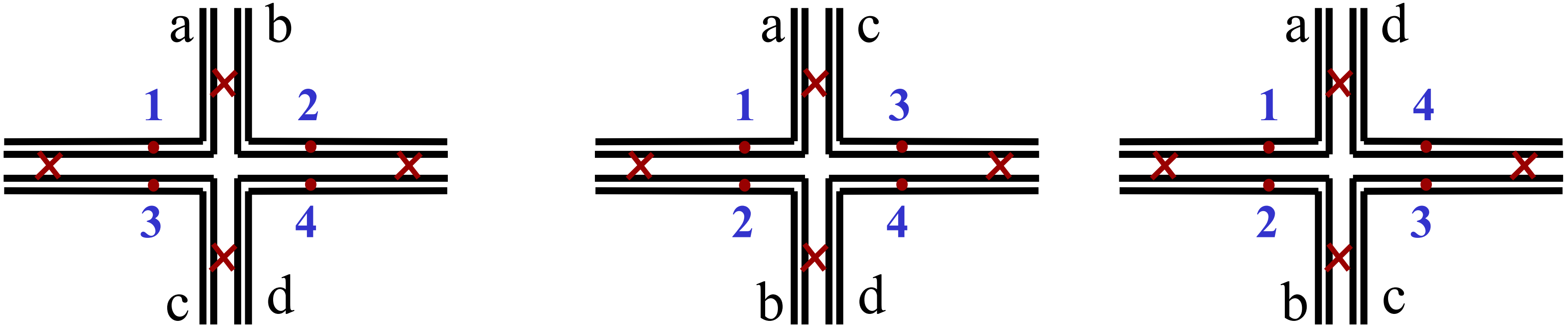
Gametic frequency:

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


a
b
1
2
3
4
c
d
O.K.
a
c
1
3
2
4
b
d
a
d
1
4
2
3
b
c
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

Chromosome segregation in autopolyploids

Random chromatid assortment:

Gametic frequency:

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

---

Example: AAaa (=abcd)

Gametes are:

aa = AA
bb = AA
cc = aa
dd = aa
} X 3

ab = AA
cd = aa
ac = Aa
bd = Aa
ad = Aa
bc = Aa
} X 10

→

or 16 AA : 16 aa : 40 Aa

or 2 AA : 2 aa : 5 Aa

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

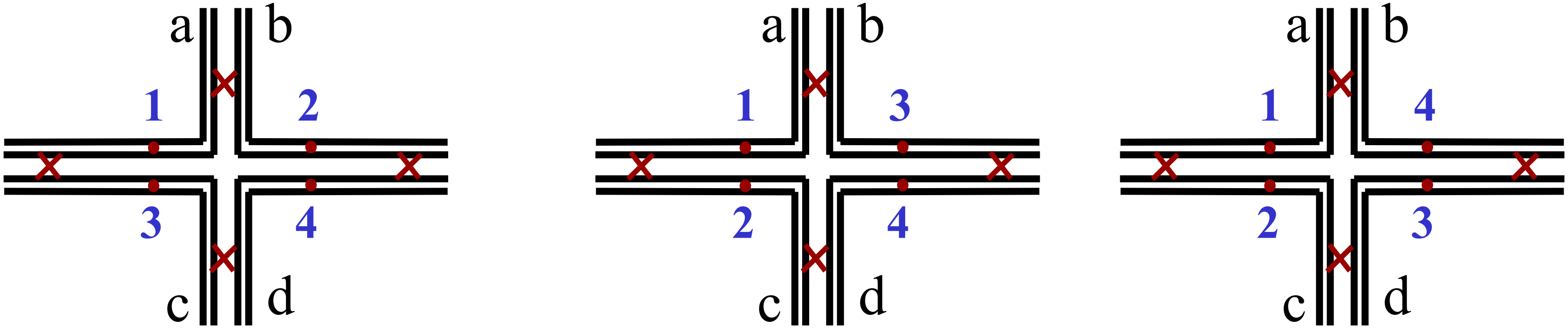
Genotype	Chromosome segregation	% rr	Maximum Equational Segregation	% rr
AAAa	AA + Aa	0	13 AA + 10 Aa + aa	4.2
AAaa	AA + 4 Aa + aa	16.7	2 AA+ 5 Aa + 2 aa	22.2
Aaaa	Aa + aa	50.0	AA + 10 Aa + 13 aa	54.2

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

Triplex and simplex	4.2%
Duplex	5.5%

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

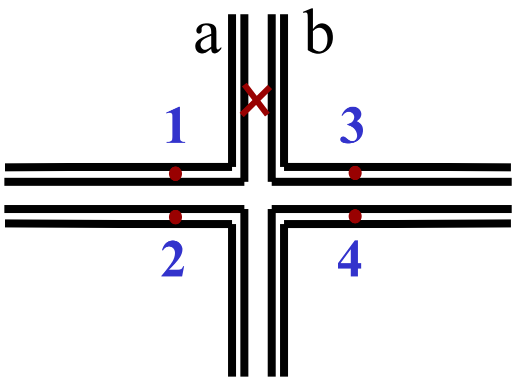
Highest frequency of double reduction gametes also called <u>Maximum equational segregation</u>

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 = $1/2 \times 1/3 = 1/6$

Double reduction gametes are 12/72 or 1/6

Highest frequency of double reduction gametes also called Maximum equational segregation

$$1/2 \times 1/3 = 1/6$$