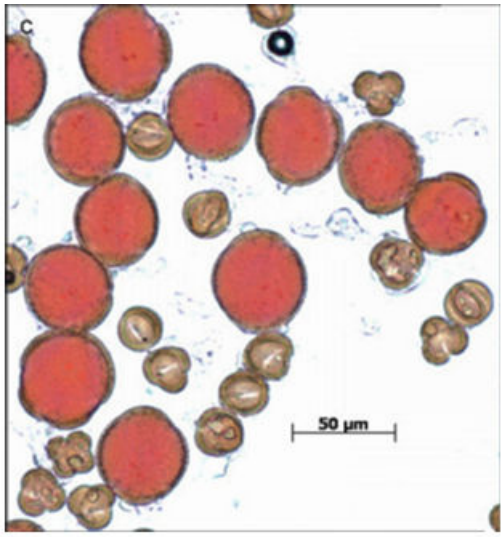
72. The following is from:

Mason AS, MN Nelson, G Yan and WA Cowling. 2011. Production of viable male unreduced gametes in *Brassica* interspecific hybrids is genotype specific and stimulated by cold temperatures. BMC Plant Biology 11:103.

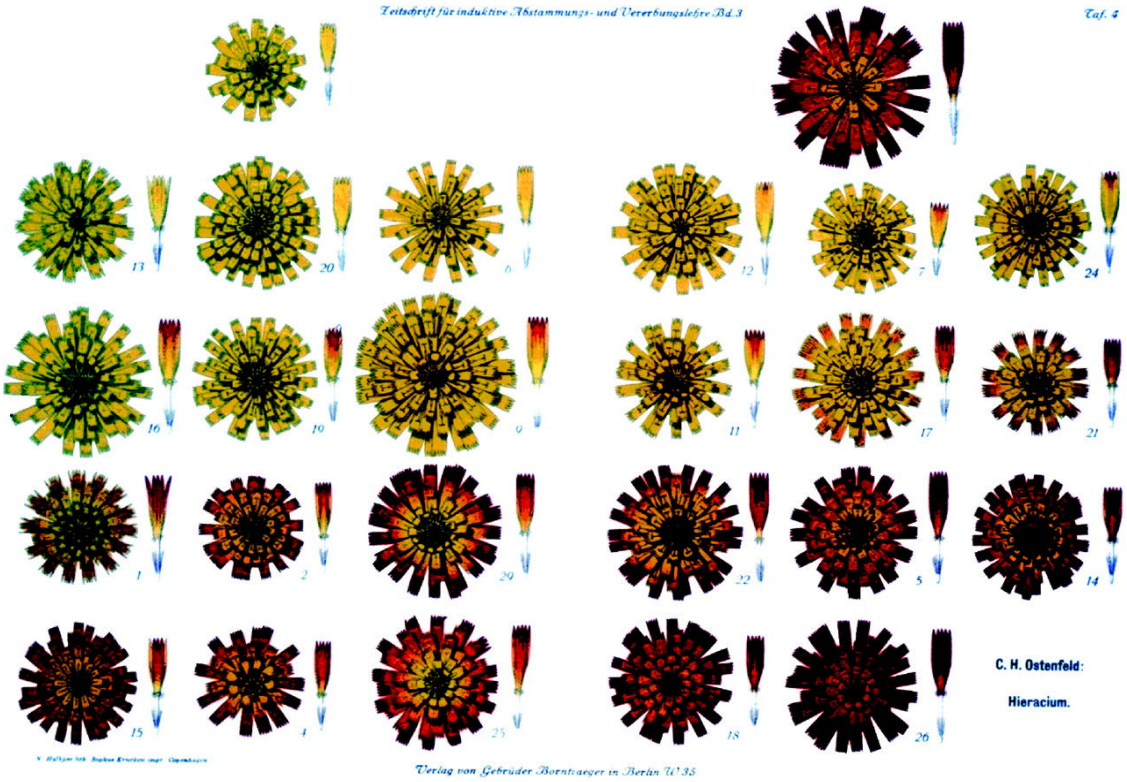


Point out three *n* and three 2*n* pollen grains in the photo.

Note: *The small, brown grains are aborted pollen grains, and lack cytoplasm, hence, no staining.*

73. The following is from:
Nogler GA. 2006. The lesser known Mendel: his experiments on *Hieracium*. Genetics 172:1-6.

In order to verify his pea work, Mendel selected *Hieracium*, as plants differed for several traits, and unless crossed together, the seed all gave plants like the parents. Both of these traits are also true of pea. Below are two parents used by Mendel, and the F1 progeny. Unlike F1 progeny from pea, those from *Hieracium* segregated:



Hieracium auricola, *H. aurantiacum*, the F1 progeny from reciprocal crosses. The figure is from Ostenfeld (1910), who recreated Mendel's cross.

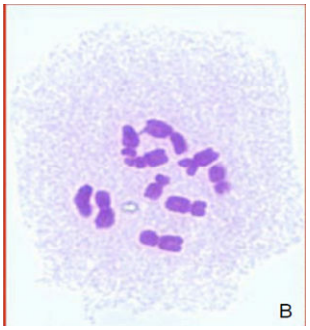
Knowing what is known today, explain Mendel's results, ie:

A) why were the F1 progeny segregating, and

B) why did the parents breed true, and how does this differ from why peas breed true.

74. The following is from:

Tang, Q-L et al., 2009. Study on haploid inducting and its meiotic abnormality in maize. Agricultural sciences in China. 8: 1159-1165.



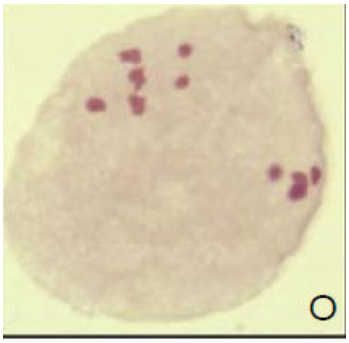
In this paper, the authors were studying monoploid maize (root tip photo B), which they noted was highly sterile.

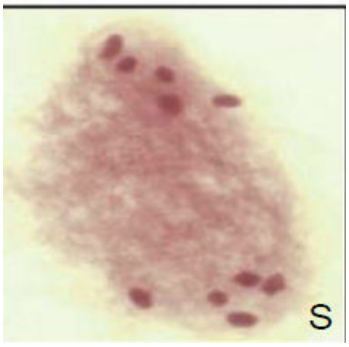
A) The cell pictured in B is _____n = _____ x = _____C = 10

or _____n = _____ Cx = _____C

B) If they were to self-pollinate these plants, what would be the frequency of seed set? Show your calculations

C) The two photos below show 2 pollen mother cells near Met II. One has a 6 to 4 disjunction, the other has a 5 to 5 disjunction. Why don't all PMC's have the 5 to 5 disjunction?





Extra credit.

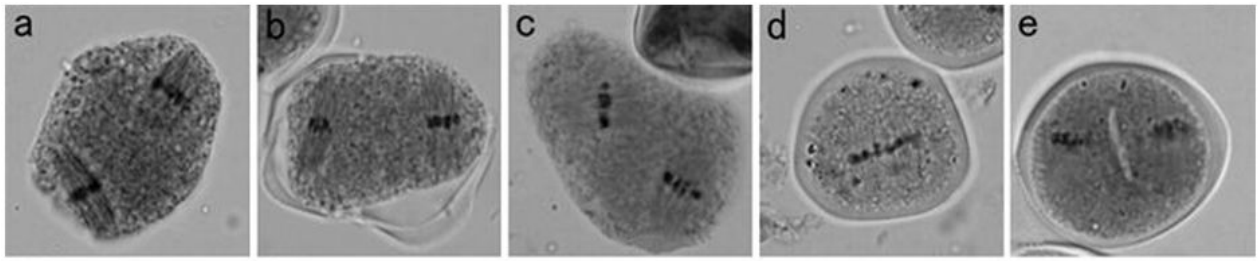
A) What percent of microsporocytes would show the disjunction as shown in figure O?

B) What percent of microsporocytes would show the disjunction in figure S?

Show your work on the next page

75. **The following is from:**

Zhang Z and X Kang. 2010. Cytological characteristics of .... Euphytica 173:151-159.



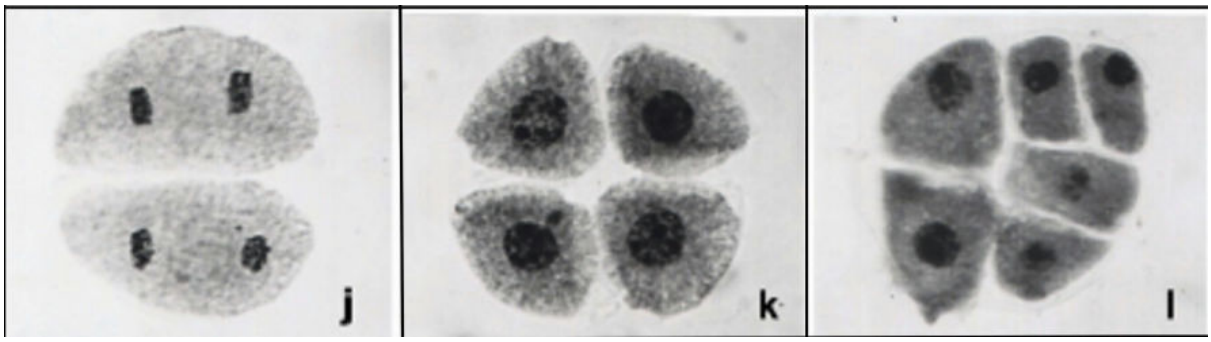
Pictured are PMCs at Met II.

A) Based on photo a, is this species a monocot or a dicot? What is the diagnostic feature?

B) For each photo, give the configuration of the sporad, ploidy and mode of each spore after Telo II?

69. The following is from:

Boldrin et al., 2011. Meiotic behaviour in [ ] accessions of [ ] and implications for breeding. Genetics and Molecular Research 10:169-176.

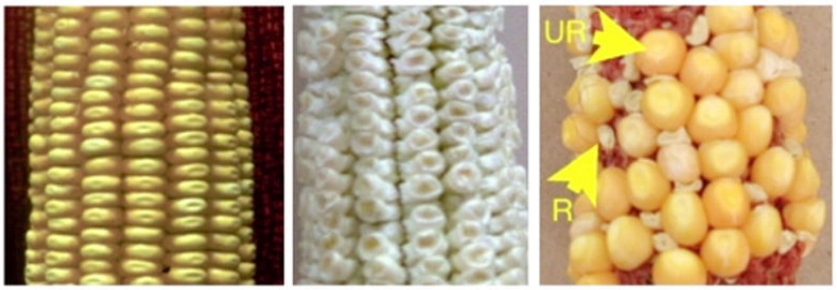


A) Based on photos j and k, is this species a monocot or a dicot? What are the diagnostic features?

B) What is shown in photo I? What inferences can you draw about what led to what is seen in photo I?

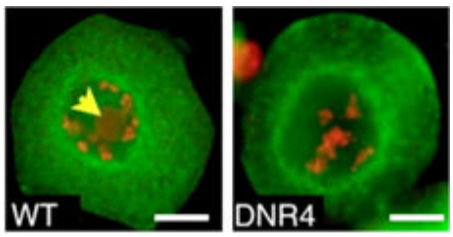
77. **The following is from:**

Singh et al., 2011. Production of viable gametes without meiosis in maize deficient for ARGONAUTE protein. Plant Cell 23:443-458.



Left: 2x mutant × 2x = full seed set; **Middle:** 2x × 4x = sterile; **Right:** 2x mutant × 4x = 4x seed, meaning the mutant is producing 2n pollen.

The green figures are of diakinesis of the wild type 2x and the 2x mutant. The arrow head shows the nucleolus. The text claims that chromosomes do not appear as condensed in the mutant.

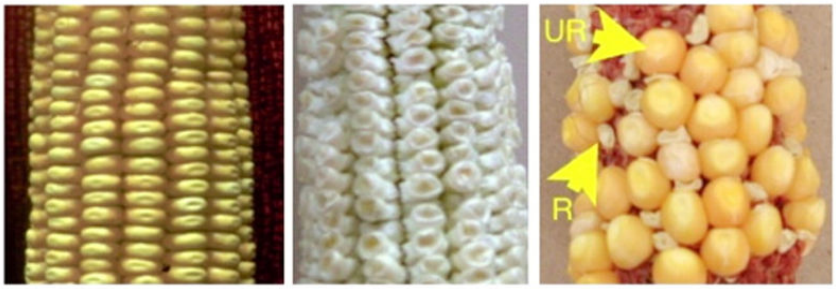


The text goes on to discuss various abnormalities during meiosis, and then states that while a couple of these "have the potential to give rise to unreduced gametes, although only restitution of meiosis I will produce unreduced gametes that are exact genetic clones of the mother plant."

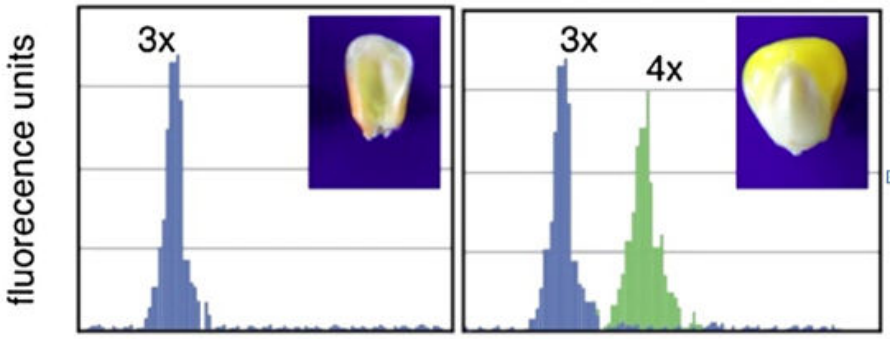
Evaluate the accurateness or lack thereof of the statement in quotes.

78. **The following is from:**

Singh et al., 2011. Production of viable gametes without meiosis in maize deficient for ARGONAUTE protein. Plant Cell 23:443-458.



Left: 2x mutant × 2x = full seed set; **Middle:** 2x × 4x = sterile; **Right:** 2x mutant × 4x = 4x seed, meaning the mutant is producing 2n pollen.



Flow cytometry results for embryos dissected out of (left) seeds from the middle cob in the picture, and (right) from shriveled (blue peak) and full grains (green

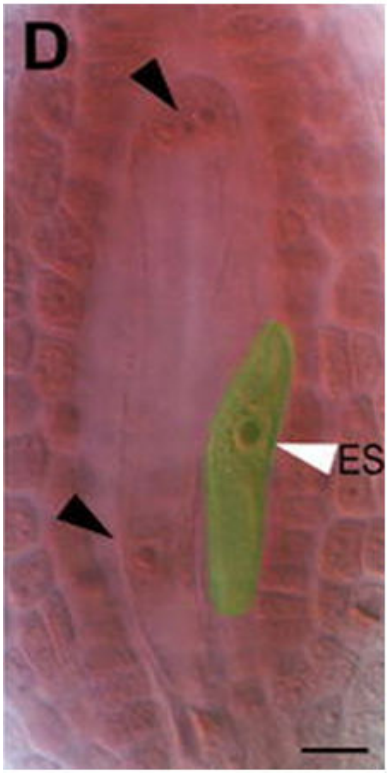
A) Give an overview of the procedures that would have been used to get the flow cytometry results, including the type of dye used.

B) Explain how the methodology would need to be modified in order to get absolute rather than relative measurements of nuclear DNA content.

C) If had done flow cytometry on the endosperm from the seeds in the cob at top left, what would the peak look like? For endosperm from seeds from the cob on right?

79. **The following is from:**

Galla et al., 2011. The cytohistological basis of .... in *Hypericum perforatum* L. Sexual Plant Reproduction 24:47-61.



In this figure, the 2 black arrows are pointing to the nuclei in a megagametophyte at the 4-cell stage.

A new MMC has formed along it (colored green).

What type of apomixis does this photo show? Explain the particular features/traits you used to arrive at your answer.

80 **The following is from:**

Storme & Geelen, 2011. The arabidopsis mutant *jason* produces unreduced ..... Plant Physiol 155: 1403-1415.

The data below are for pollen derived from F1 plants which were heterozygous for 4 SSLP molecular markers. The F1s were obtained by crossing Columbia (Col-0)with Landsberg erecta (Ler).

Thus, haploid pollen must have the allele from one parent or the other, indicated as Col-0 or Ler in the table below.

In contrast, 2n pollen can be homozygous for the alleles, indicated as Col-0 or Ler in the table below, or heterozygous (Het).

Chromosome	SSLP	Haploid Pollen				Diploid Pollen			
		N	Col-0	Het	Ler	N	Col-0	Het	Ler
III	ciw11	7	42.9	0.0	57.1	20	0.0	100.0	0.0
	nga6	9	66.7	0.0	33.3	27	33.3	48.1	18.5
V	nga76	9	44.4	0.0	55.6	29	0.0	100.0	0.0
	nga151	7	22.2	0.0	77.8	28	0.0	78.6	21.4

Based on the data in the table,

A) Is the pollen FDR or SDR? What is the basis for your answer?

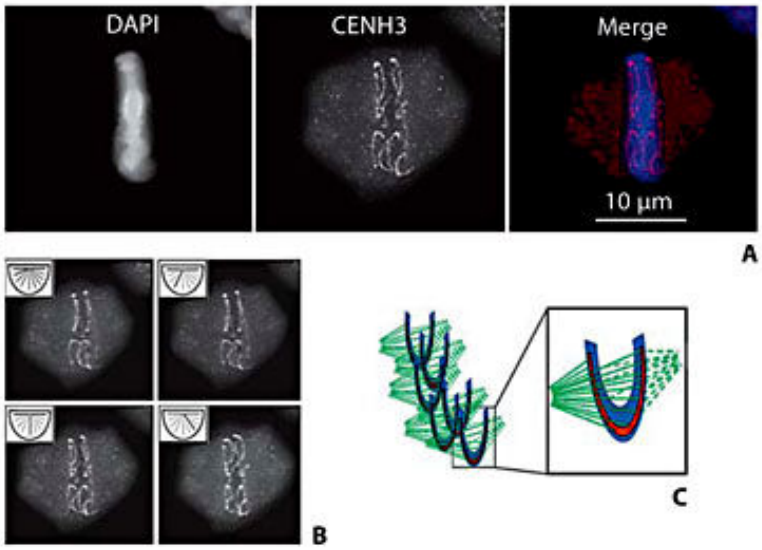
B) Without mapping the alleles, which is closer to the centromere, ciw11 or nga6? What is the basis for your answer?

81. **The following is from:**

Heckmann et al., 2011. Holocentric chromosomes of *Luzula elegans* are characterized by a longitudinal centromere groove, chromosomal bending and a terminal nucleolus organizer region. Cytogenetic and Genome Research 134:220-228.

In class we studied meiosis with centric chromosomes, that is chromosomes which the centromere in one single spot. It is well known that sedges and a few other plants, along with several insects, have holocentric chromosomes, that is, chromosomes with a centromere along their entire length.

In this study, the authors used antibodies specific to CENH3 and found the centromere of holocentric chromosomes is really in a groove along the length of the chromosomes.



Identification of the centromeric groove in a holocentric chromosome, and depiction of the way in which the spindle

A) Describe the relevance of using antibodies to CENH3.

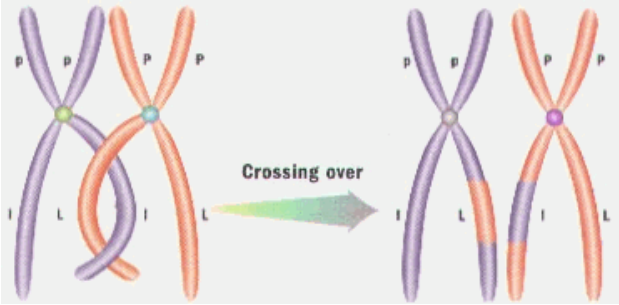
EC) Organisms with holocentric chromosomes also exhibit a phenomenon called 'inverse meiosis' whereby the equational and reductional divisions occur in reverse order from standard meiosis.

Though inverse meiosis was not covered in class this year, anyone with a good understanding of meiosis should be able to figure it out easily.

For an organism with 2n = 2Cx = 2, diagram inverse meiosis. Show two distal crossovers per chromosome. Be sure and label the parts of the chromosome undergoing equational and reductional separations.

82. **The following is from:**

Materials used in the Fayette county public school system in Kentucky: http://staff.fcps.net/cverdecc/adv%20biology/notes/meiosis/meiosis%20notes.htm, accessed 19 Sept 2011.



A) Describe TWO issues that are wrong with the diagram

B) Provide a diagram of the way it should be

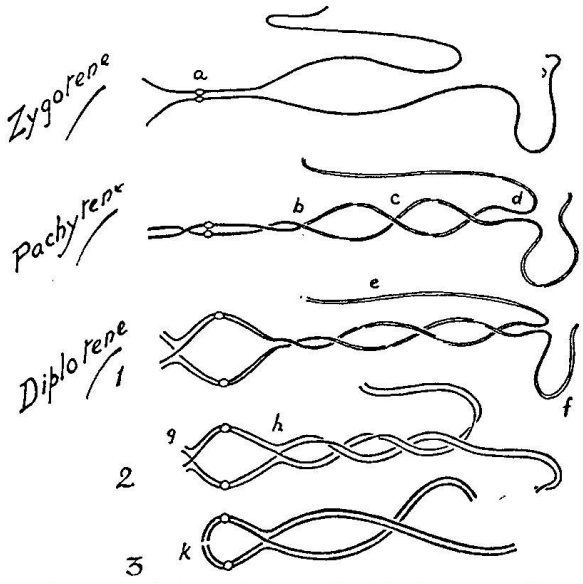
83. The following is from:

Darlington, 1935. Recent Advances in Cytology. Garland Publishing, Inc.

The diagram shows various chiasmata from stage 1 that get terminalized in stage 3.

He describes terminalization as 'chiasmata are no longer interstitial–they have been gradually pushed along to the ends of the chromosomes.'

Given what is known today about chiasma formation, why is Darlington's concept of terminalization not viable? Give 1 reason.



84. **The following is from:**

Li and Pfeiffer. 2009. Three cycles of recurrent selection for altered recombination frequency in maize. Crop Science 49: 473-482.

In corn, a lot of inbred lines are derived from, and a lot of research is done with, the BSSS (Iowa Stiff Stalk Synthetic) population. Individuals within BSSS are known to differ in recombination frequency. Therefore, the authors did 3 cycles of recurrent selection to either increase or decrease recombination between gene pairs on different chromosomes. Sample data are below:

For *a2-bt1*, original = 4.6 cM; High population = 6.2 cM, and Low population = 2.9 cM. Differences were significant at $p < 0.00001$.

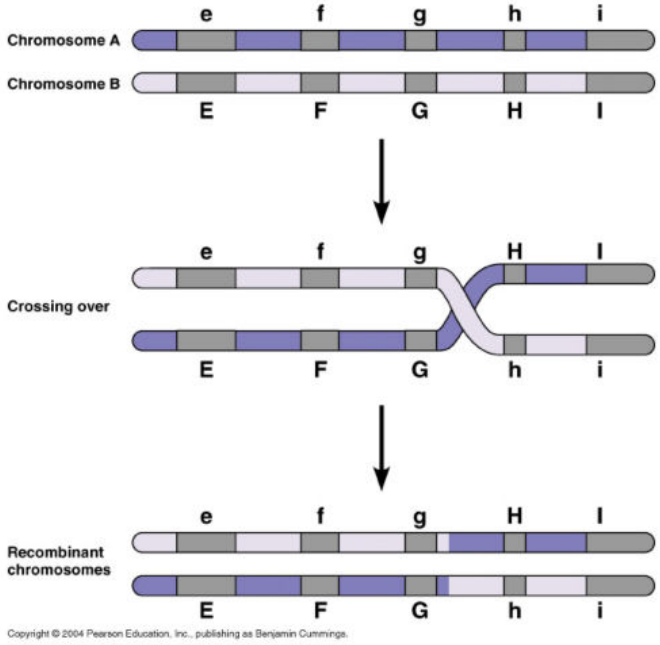
For *bz1-wx1*, original = 1.9 cM; High population = 2.2 cM, and Low population = 1.9 cM. P values were 0.14 for the high population, and 0.71 for the low population.

In class we reviewed environmental, genetic and structural factors that could affect recombination rates. Briefly describe 2 of these, and explain why they would be consistent with all the data,

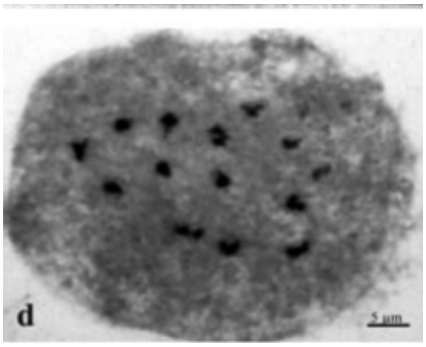
.

85. **The following is from:**
classes.midlandstech.edu

Is this an accurate model of recombination? If not, please diagram an accurate model.

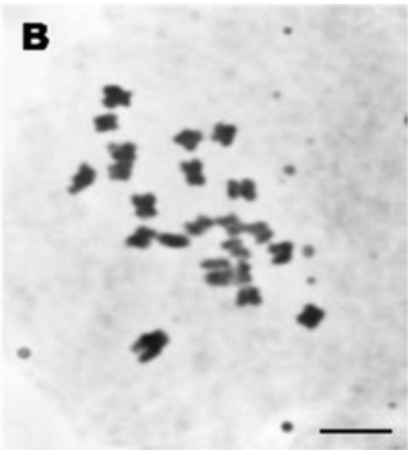


86. **The following is from:**
Marques de Resende et al. 2013. Chromosome number and meiosis in populations of *Senna* species (Caesalpinioideae – Fabaceae) from Southeast Brazil. Caryologia 66: 1–5.



and

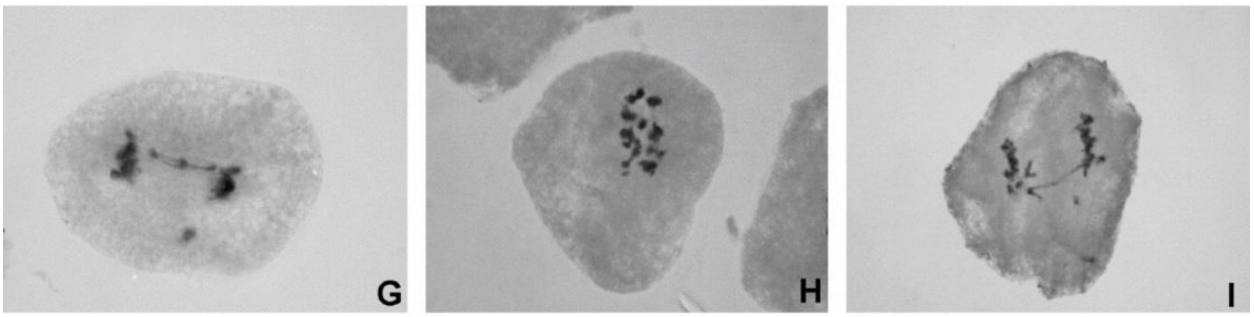
Pierozzi 2013. Orcein, C- and NOR-banding on mitotic chromosomes of some wild diploid coffee species (*Coffea* L.). Caryologia 66:76-83.



The top photo is a PMC from *Senna alata*.
What stage is shown? _____
The cell in the photo would have
_____n = _____ = _____ x = _____ c

Contrast with the root tip cell from *Coffea eugenioides*
What stage is shown? _____
The cell in the photo would have
_____n = _____ = _____ x = _____ c

87. **The following is from:**
Via do Pico. 2012. Chromosome number, meiotic behavior and pollen fertility of six species of *Chrysolaena* (Vernonieae, Asteraceae). Caryologia 65: 176-181.



Figures G and I are the classic bridge and fragment configuration.

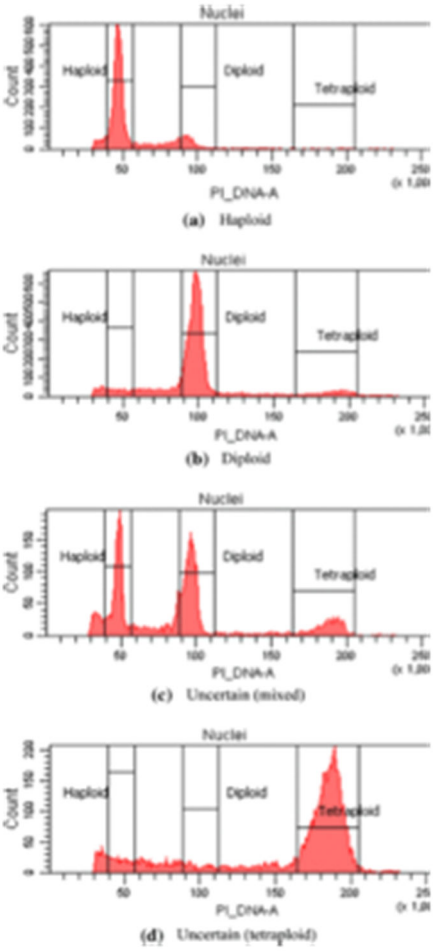
A) What 2 scenarios can give rise to this configuration?

B) At Telo II, how many of the resulting spores will be viable? _____

C) For each case in part A, how many will be viable and recombinant?

88. **The following is from:**
Takahira et al., 2011. Improvement in efficiency of microspore culture to produce doubled haploid canola (*Brassica napus* L.) by flow cytometry. Plant Cell, Tissue & Organ Culture 104: 51-59.

In this paper, the authors exposed microspores to colchicine and then regenerated plants from the microspores in tissue culture.

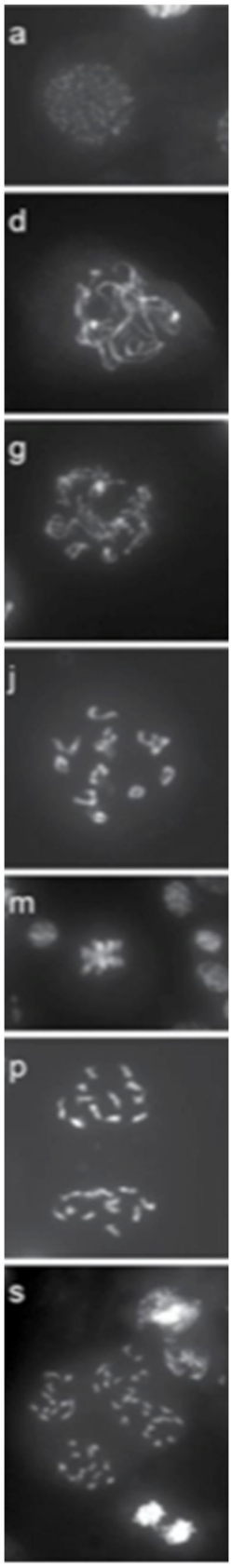


The plants regenerated were (a) haploid, (b) diploid, (c) mixoploid, or (d) tetraploid. The authors go on to say that:

"Diploid progeny produced in the control (no colchicine) treatments were homozygous at six or seven simple sequence repeat marker loci. This is consistent with the conclusion that spontaneous diploids in the control treatment are derived from post-meiotic doubling of normal haploid gametes, <snip>. The result is not consistent with their (ie, 2x plants) derivation from somatic tissue contamination or from unreduced gametes."

Are you satisfied that they ruled out an origin from unreduced gametes? Explain why or why not.

89. **The following is from:**
De Storme and Geelen. 2013. [ ] J Experimental Botany. 64:2345-2358



A) Label each stage shown in the photo and indicate by which stage most of the DNA replication is completed.

a)

d)

g)

j)

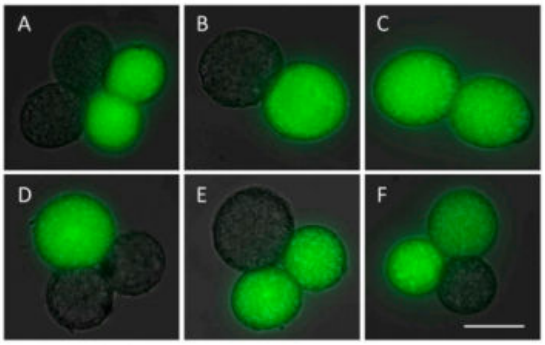
m)

p)

s)

B) Is this plant a monocot or a dicot? Explain the basis for your answer.

90. **The following is from:**
De Storme et al. 2012. Production of diploid male gametes in *Arabidopsis* by cold-induced destabilization of postmeiotic radial microtubule arrays. Plant Physiology 161:1808-1826.



In this paper, the authors used cold shock to get arabidopsis to produce 2n gametes, a finding that has important breeding applications. They used the quartet mutant of arabidopsis, whereby the individual pollen grains from any given sporad remain attached to each other. Furthermore, they had transgenes for different fluorescent proteins. The premise was to use the presence/absence of these fluorescent markers to determine the mode of 2n gamete production. The photo shows the concept.

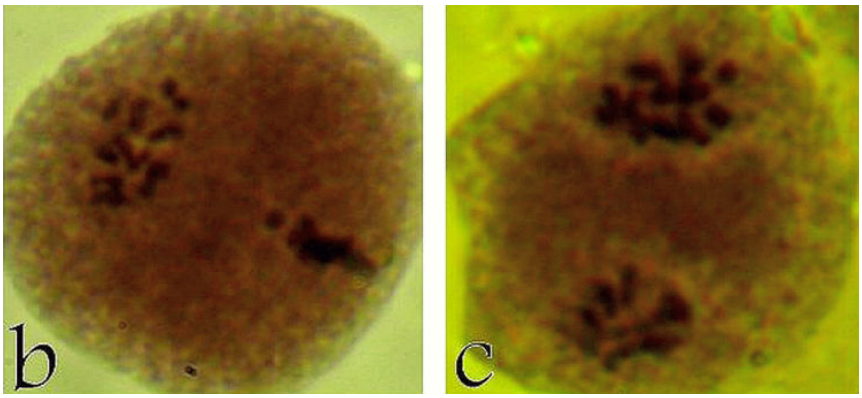
The data follow. m = the marker, - = the absence. Thus m - is heterozygous, mm and - are homozygous. So m - / m - = Fig B; mm/- = Fig C. The concept extends out the triads.

Dyads			Triads			
n	m−/m−	mm/−	*n*	mm/−/−	m−/m/−	−/m/m
			%			
21	19.0	81.0	–	–	–	–
21	19.0	81.0	–	–	–	–
121	32.2	67.8	267	33.0	36.7	30.3
121	51.2	48.8	267	22.1	52.1	25.8

Based on these results, are the gametes FDR or SDR? Explain your answer.

For the first two rows of data, what is the distance between the centromere and the transgene?

91. **The following is from:**
Khalili et al, 2012. Chromosome number and meiosis behavior in several Salix species of Iran. Caryologia 65:258-262.



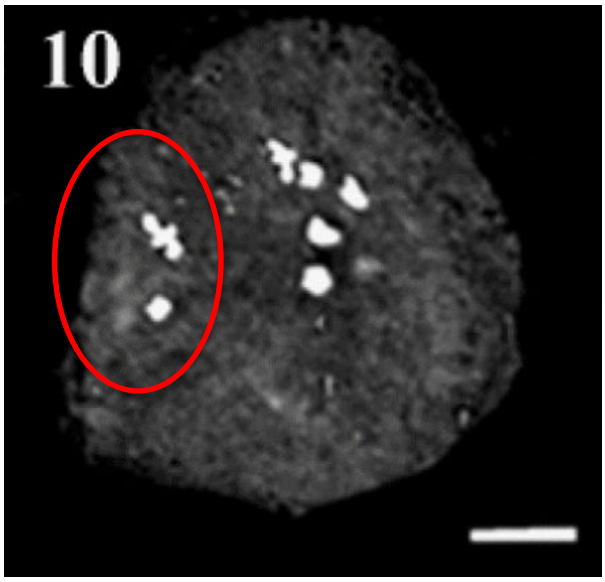
b) fusion of non-sister chromatids in one pole of *S. elbursensis*; c) the first metaphase of *S. elbursensis* with 2n=38

In this paper, the authors are investigating the origin of dyads and triads in willow (genus *Salix*).

According to the text, "We identified species that form not only tetrads, but also dyads and triads. The condition for the formation of such microspores is dependent upon the orientation of division spindles. When the division spindles are only partially separated, there may be confluences of chromosome groups. Here two alternatives are possible. If confluence of the chromosome groups occurs at both poles, then two diploid microspores are formed (Figure 2c). Fusion of non-sister chromatids in only one of the poles produces triads (Figure 2b), resulting in two haploid and one diploid gametes."

I.e., the mechanism is literally first division restitution in b and second division restitution in c. Do you agree with the authors' interpretation of their cytology? Why or why not?

92. **The following is from:**
Ranjbar et al. 2012. An overview on cytogenetics of the genus *Onobrychis* (Fabaceae) with special reference to *O*. sect. *Hymenobrychis* from Iran.



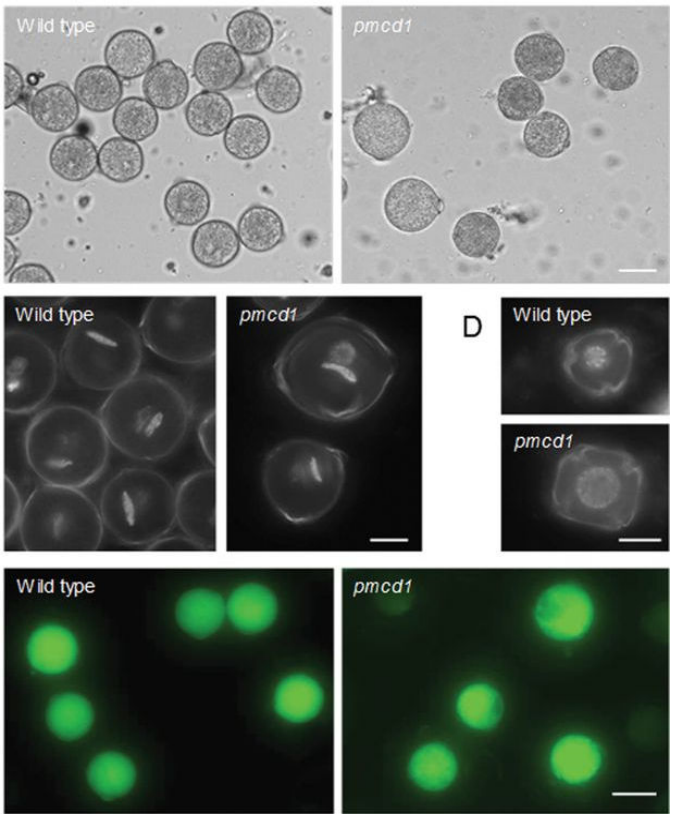
The figure at right is of diakinesis in *O. chorassanica*, 2n = 14.

A) How many chiasmata are visible?

B) Provide an interpretive drawing for the bivalents in the red circle.

93. **The following is from:**
De Storme and Geelen. 2013. [ ] J Experimental Botany. 64:2345-2358

In this paper, the authors used light microscopy, DAPI, and fluorescein diacetate to look at pollen from wild type and the pmcd1 mutant of tomato.



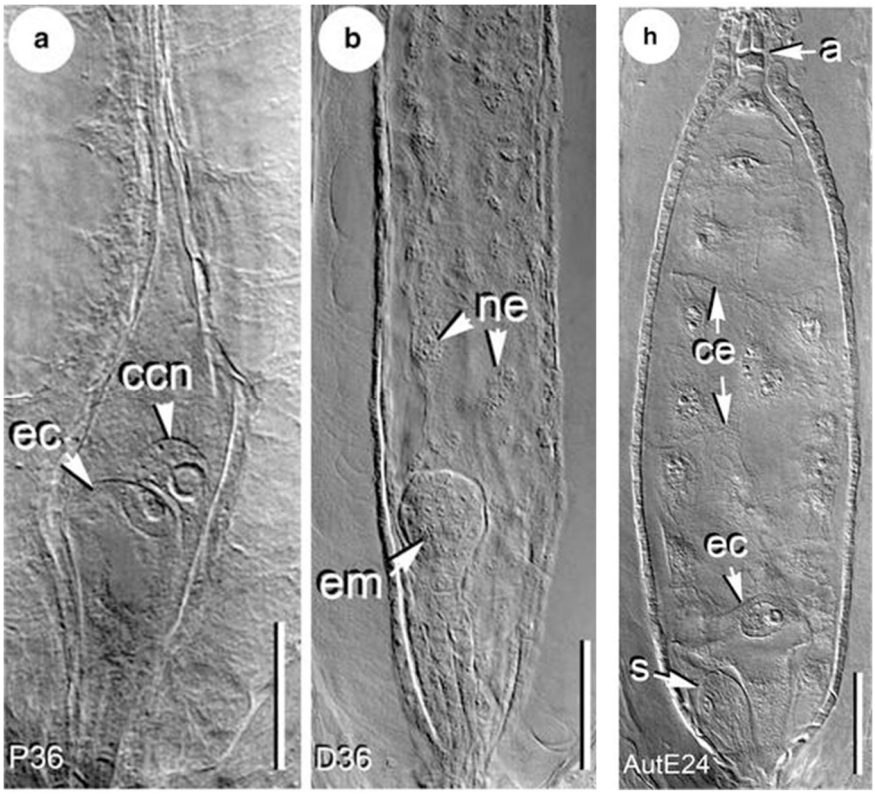
A) Based on the photos, what conclusion would you make about the pollen from the pmcd1 mutant?

B) What are 2 diagnostic features that allow you to make the above conclusion?

C) Describe 2 additional tests you would want to do to confirm your observations.

94.
The following is from:

Ogawa et al. 2013. Plant Reproduction.



Stage 10 fixed ovules from *Hieracium* in the absence of pollination a) mature embryo sac, b) embryogenesis and embryo development, h) start of endosperm cellularization. Within each image: a antipodals, ccn central cell nuclei, ec egg cell, ne nuclear endosperm, em embryo, ce cellularizing endosperm, s synergid. Bar 100 µm

A) The processes shown in b) is

_____.

B) What is the most definitive way one could test to verify if the above answer is correct?

C) Why is the phenomenon from b) more common in the polyploid members of the genus?

D) Is this an individual (b) you would like to incorporate into a breeding program? Why or why not?

95. The following is taken from the 1922 classic work of Hutchison, reproduced in Sinnot & Dunn. 1939. Principles of Genetics. McGraw-Hill Book Company, New York and London. Image from http://www.dlqiankun.com/Product/EnDetail/19.html

In maize, F1 plants from the cross of colored, shrunken, starchy x colorless, full, waxy were crossed with colorless, shrunken, waxy plants, and the following progeny were observed:

Colored, waxy, starchy	2,538
Colorless, full, waxy	2,708
Colored, full, waxy	116
Colorless, shrunken, starchy	113
Colored, shrunken, waxy	601
Colorless, full, starchy	626
Colored, full, starchy	4
Colorless, shrunken, waxy	2

A) Map the positions of c, s and w

B) Determine the coincidence

96. **The following is from:**
Kleiber et al., 2012. . Crop Science. 52: 623-630.

The premise is that they can simplify doubled haploid production by selecting haploid genotypes of maize that produce high frequencies of monoploid gametes.

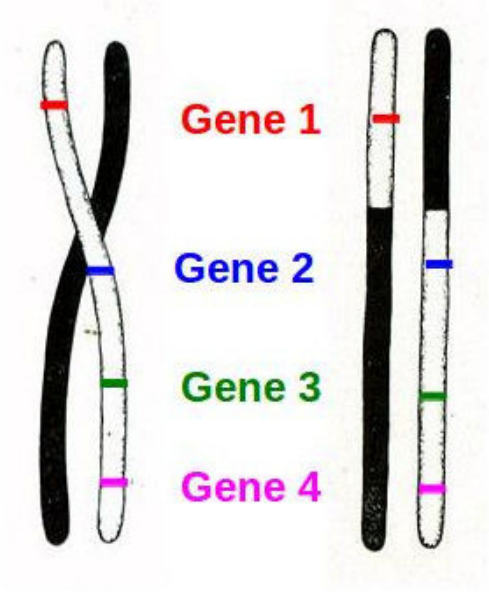
A) What is the expected seed set from monoploid maize (ie, selfing a haploid plant)? Show your work.

B) The number of intact seeds in fertile monoploid maize populations is shown in the table at right (ie, seed set after selfing a haploid)

Give a biologically plausible hypothesis as to what might be happening. Explain how you would test your hypothesis.

	Mean ± SE
Population type	
Landrace	0.30 ± 0.13 a‡
Open-pollinated variety	0.72 ± 0.23 ab
Elite single cross	1.18 ± 0.36 b
Maturity group#	
Early	0.60 ± 0.29 a
Medium	0.60 ± 0.25 a
Late	0.78 ± 0.19 a

97. The following is from: http://www.howdoweknowit.com/

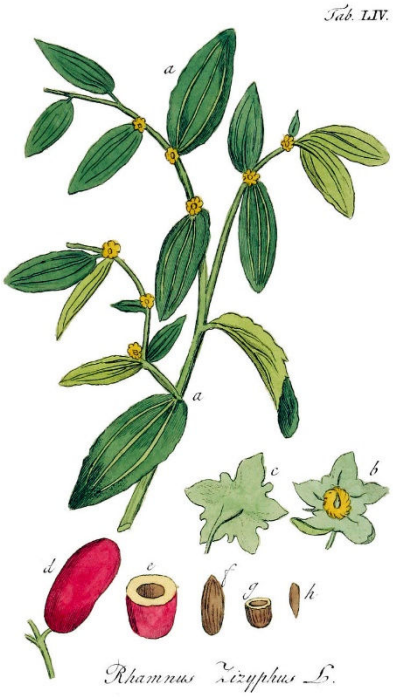


A) What type of genetic results are not explainable by the above model?

B) Redraw the figure to correct it.

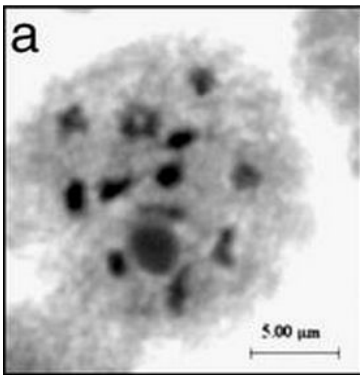
98. **The following is from:**

Xue X, P Liu and M Liu. 2011. Cytological mechanism of 2n pollen formation in Chinese jujube (*Ziziphus jujuba* Mill. 'Linglingzao'). Euphytica 182: 231-238.



Jujube, pictured at right, is used in Chinese herbal medicine.

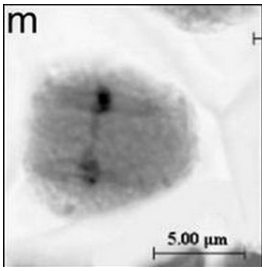
A. Based on the PMC in photo a), jujube is ___n = 2x =___C = ____.

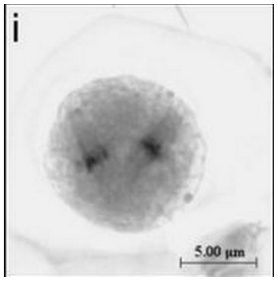


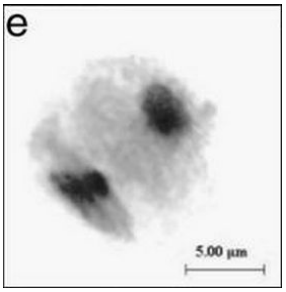
B. What stage of prophase is shown?

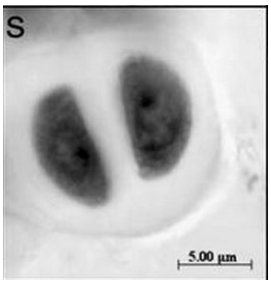
C. Based on all the PMC meioses photos below, is this species a monocot or eudicot? What is the diagnostic feature used for your answer?

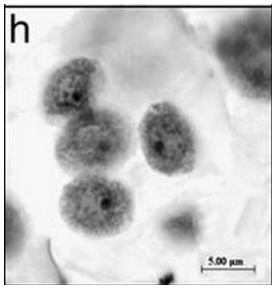
D. Match each Met II cell to its corresponding polyad, & name the mechanism for m and i.

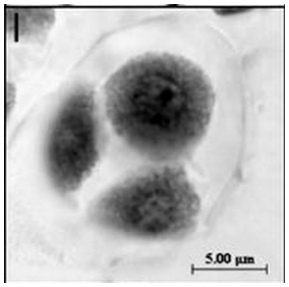








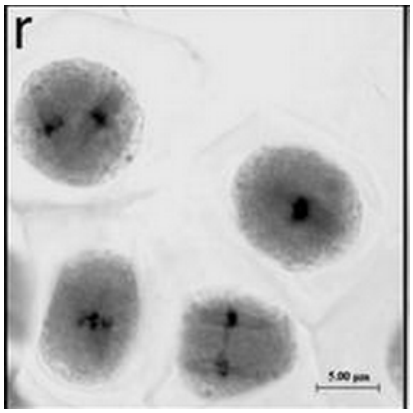




E. In h) each spore will be _____ n = 2x =_____C = ____.

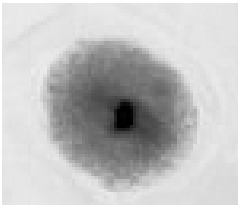
F. In s), each spore will be _____ n = 2x =_____C = ____.

G. Two PMCs in the photo at right correspond to **m** and **i**, above. What is the mechanism seen in the other two cells?



H. What is the mode of 2n pollen formation in this plant? What led you to that conclusion.

I. Extra Credit: The photo at right is cropped from r, above. Diagram out meiosis in this cell and briefly explain what happens at each stage. Start at Met I and for brevity, just use 1 pair of chromosomes.



99. **The following is from:**
Landry et al., 1987, A genetic map of Lettuce (*Lactuca sativa* L.) with restriction fragment length polymorphism, isozyme, disease resistance and morphological markers. Genetics. 116: 331-337.

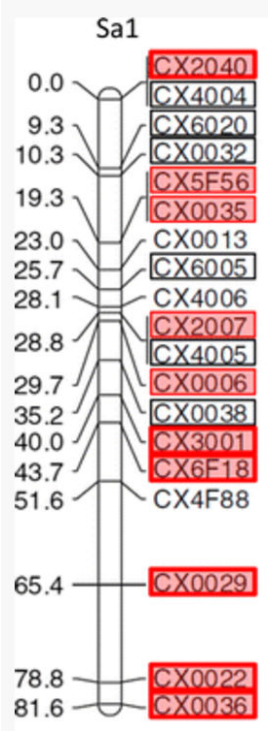
66 F2 individuals in a cross between two lettuce cultivars produced the genetic map based on RFLP markers, seen at right. Numbers to the left of linkage groups represent recombination frequency (i.e., cM).

A) Looking at markers CL658, CL6635, and CL537 on the top of linkage group 1, what is the expected **frequency** of double crossovers?

B) How many individuals on average would Landry et al., 1987 need to screen in order to detect 3 double crossovers in this region if there was no interference?

C) Extra Credit: How many individuals would Landry et al., 1987 need to screen in order to detect 3 double crossovers if I = 0.20?

100. The following is from:
Honsho et al., 2016. Single-pollen genotyping to estimate mode of unreduced pollen formation in *Citrus tamurana* cv. Nishiuchi Konatsu. Plant Reproduction 29: 189-197



At left is the marker map for chromosome 1. As is the case with all marker-based maps, the centromere cannot be mapped.

Thus, they resorted to 2n gametes in order to map the centromere. They genotyped 74 2n pollen grains, and determined which percent of 2n pollen grains were heterozygous for the markers with the strong red box on the map. The other markers did not amplify well enough to be tested. The data are in the table below.

A. For each marker, what is the gene-centromere distance for each mode? Enter the values in the table.

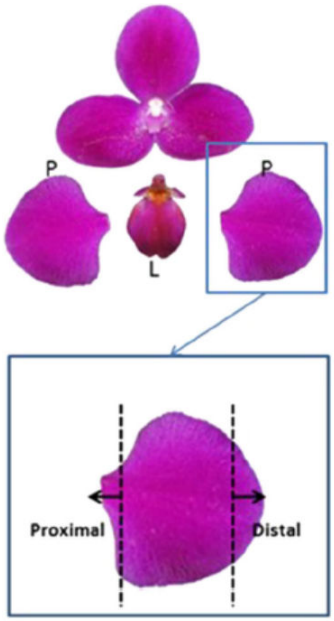
B. If the gametes are FDR, can you determine which 2 markers flank the centromere, and if so, list them

C. If the gametes are SDR, can you determine which 2 markers flank the centromere, and if so, list them

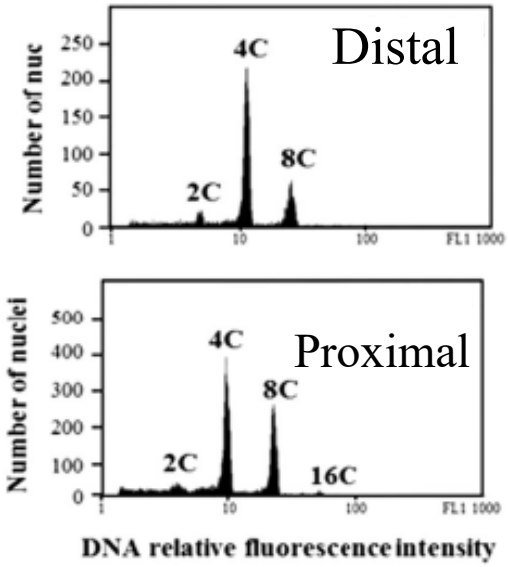
D. What is the mode of 2n pollen formation in this example? What led you to that conclusion?

E. Extra credit: Can the mechanism be inferred from this information?

	Marker-2040	**Marker-3001**	**Marker-6F18**	**Marker-29**	**Marker-22**	**Marker-36**
% pollen grains heterozygous at this locus	64.9	74.3	56.8	56.8	52.7	50
cM distance to centromere (FDR)						
cM distance to centromere (SDR)						

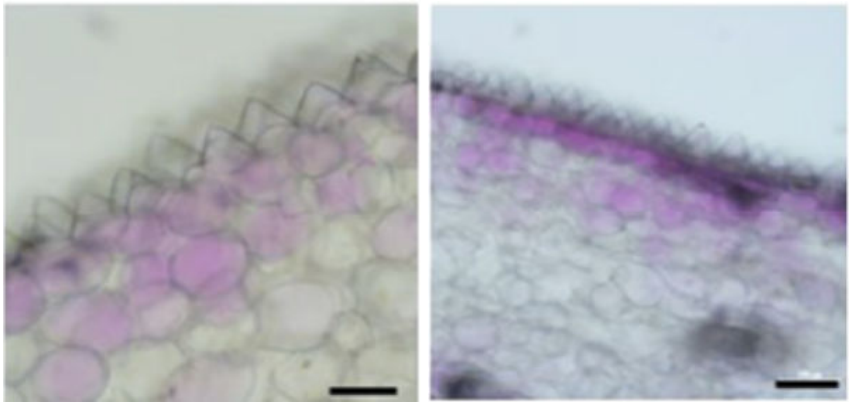


101. The following is based on: Ho et al., 2016. { } level affects flower size and development by incraseasing cell size in *Phalaenopis* and *Doritaenopsis*. Acta Physiol Plant. 38:190
In this paper, the authors looked at cell size in orchid flower petals, as well as flow cytometry for *Phalaenopis* hybrids



The authors also did histology.

A. Based on the flow cytometry results, which photo below is from the distal end and which is from the proximal? In 1 sentence, explain your answer.



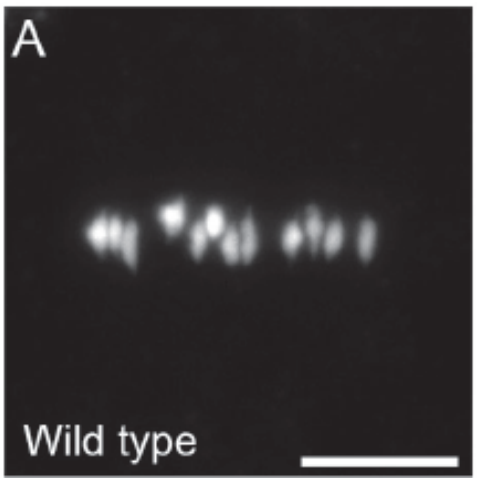
B. What is the name of the condition seen and name one benefit to the plant of this condition?

C) **Name** and **diagram** out the process that creates a result as seen within individual 1.

D) Extra Credit: Describe how the flow cytometry results were generated. Samples were stained with DAPI in this work. Remember to discuss how light wavelengths get filtered in the process.

102. The following is from:

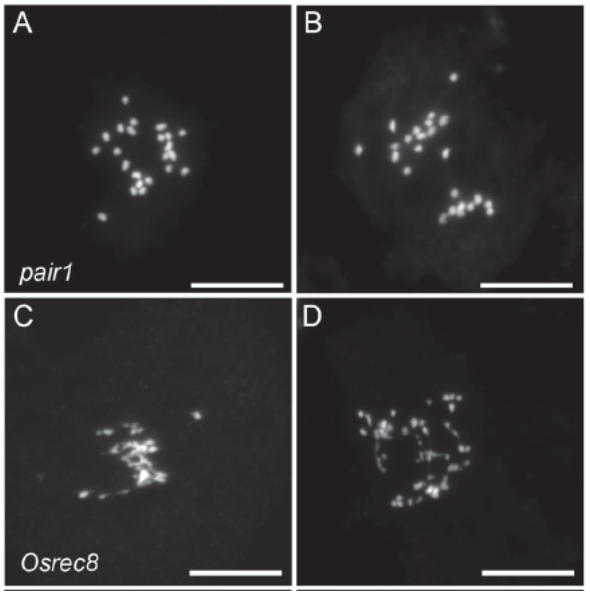
Mieulet et al., 2016. Turning rice meiosis into mitosis. *Cell Research* 1-13



The authors used knock out mutants of 3 rice genes to convert rice meiosis into mitosis. Their goal was to introduce apomixis into rice, by knocking out meiotic genes originally discovered in *A. thaliana*.

A) The image at right shows _____ stage of meiosis. Based on that image rice is 2n = 2x = _____

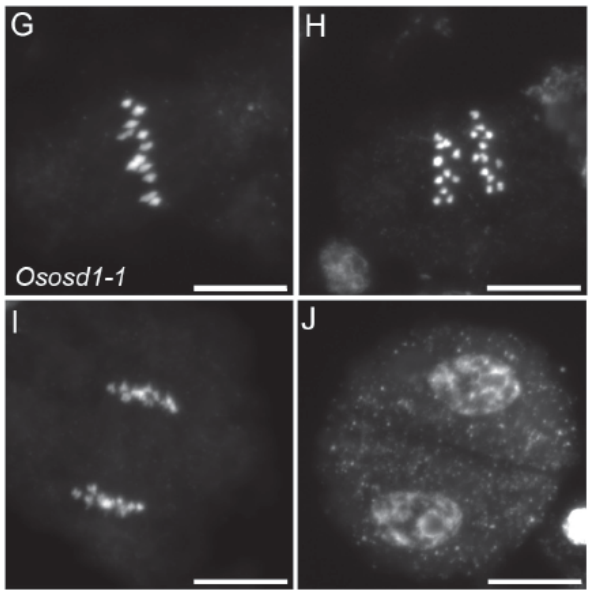
To the right are pictures of metaphase I (left) and anaphase I (right) for two rice mutants. All plants are 2x



i. What is seen in panels A+B?

ii. EC: What is happening in panels C+D?

The panel to the right shows in one of the mutants: metaphase I (G), early (H) and late (I) anaphase I, and telophase I (J) in a rice meiotic mutant. Meiosis II is omitted in this mutant.



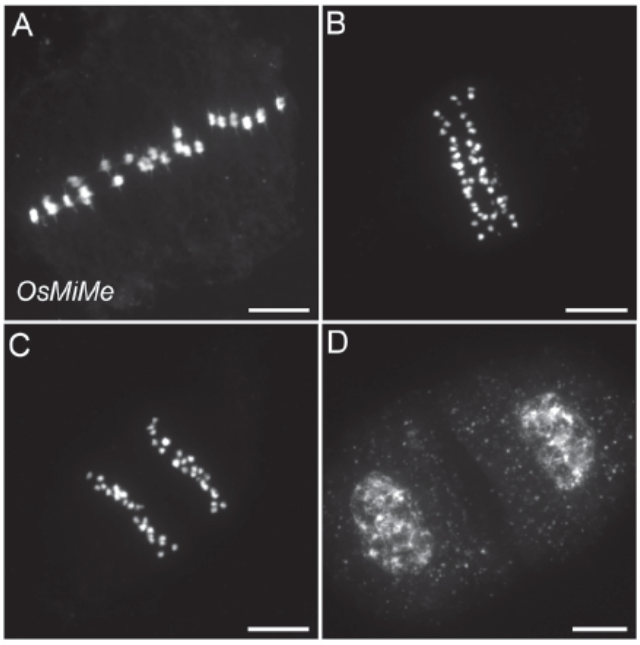
B) What is the mode of 2n gamete formation? Explain your answer.

C) Compare meiosis in the photo set below (from the rice triple mutant) with the one above. They show the same stages

i. What is lining up at the metaphase plate in G as compared to A?

ii. What is separating in H/I as opposed to B/C?

iii. What is the mode of 2n gametes in D)?



iv. Would it be proper to refer to the gametes in D as unreduced? Why or why not?

v. Summarize why the authors say meiosis became mitosis

vi. What is missing before this becomes apomixis?

103 The following is from Thinglink.com:

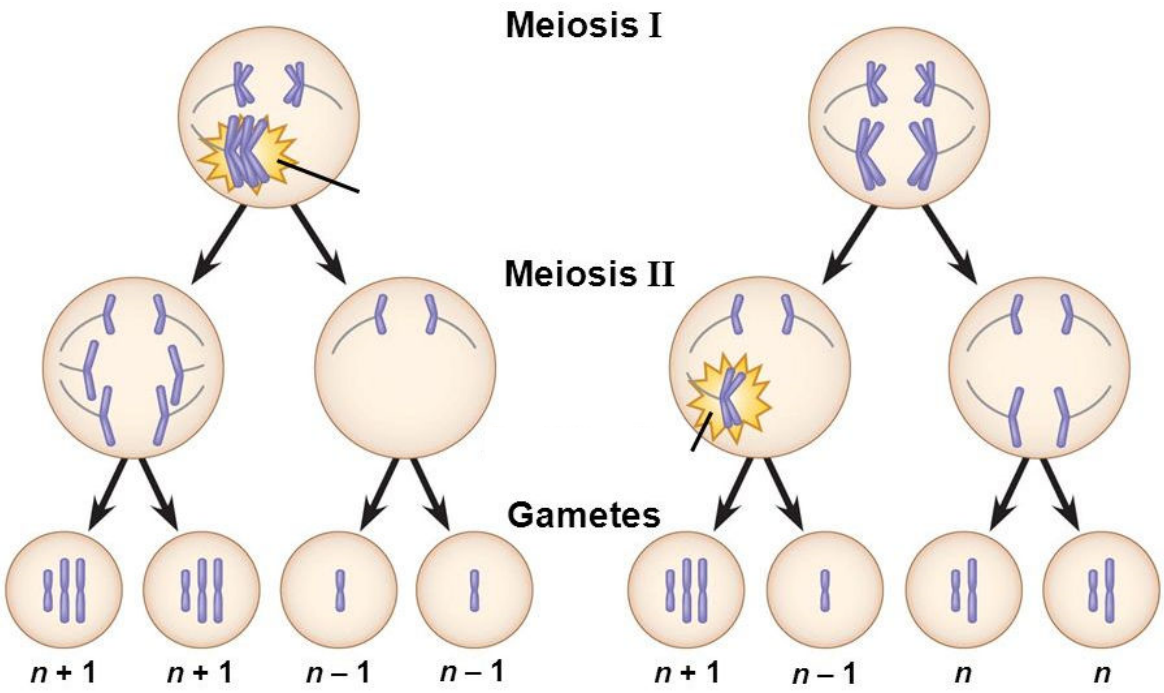
Name the phenomenon indicated by the yellow flash in

Meiosis I =

Meiosis II =

Each answer is a 2-word term

B. Explain how this phenomenon confirmed that genes are located on chromosomes. Answer should not exceed the space allotted here.

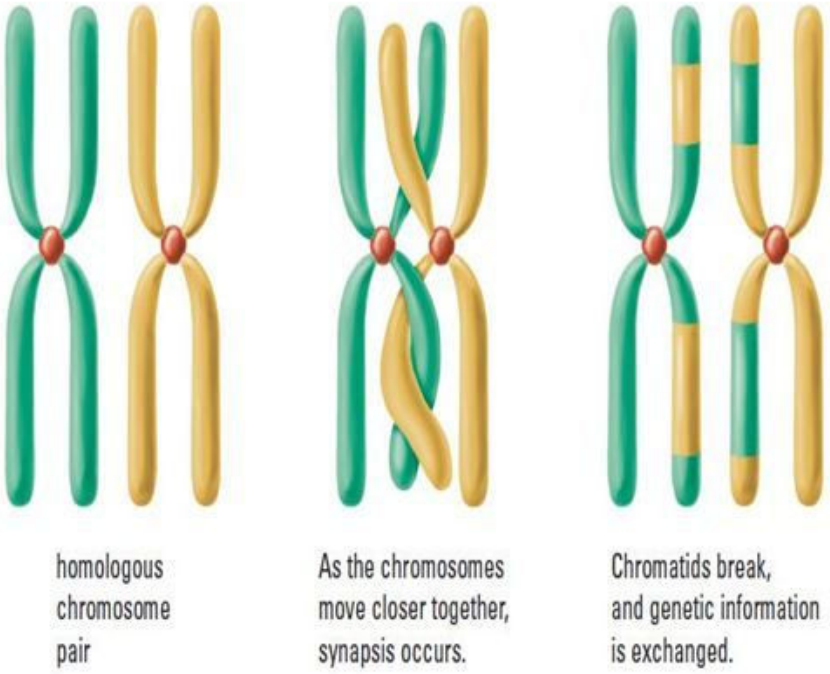


https://www.thinglink.com/scene/726874405988204544

104. The following is from:

https://uoitbio2013.wordpress.com/mitosis-vs-meiosis/meiosis/

It contains at least 3 glaring errors. Describe them.

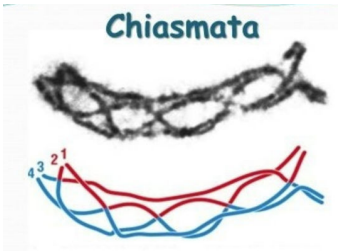


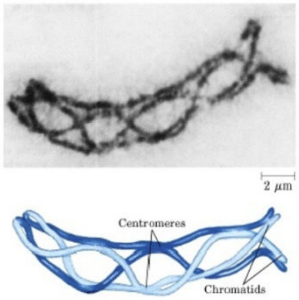
105. The following was provided by Prof. John Bernard:

You have pinned it to your bulletin board. Knowing your interest in plant genetics, your friend comes along and says "Amazing number of crossovers in plants!"

A) Explain why you would agree or disagree with your friend.

B) A couple interpretations of this photo are floating around the internet. Which one below is the correct one, and why?





http://editimage.club/heets201121.html

https://biology.stackexchange.com/questions/42288/do-only-one-or-both-pairs-of-homologous-chromatids-exchange-genetic-material-dur

106. The following is a headline that appeared in the news section of the journal *Nature*

NATURE | NEWS

Gene drives thwarted by emergence of resistant organisms

Until this obstacle is overcome, the technology is unlikely to succeed in the wild.

Ewen Callaway

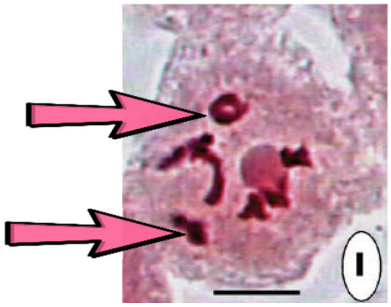
31 January 2017

This article discusses potential shortcomings of recent CRISPR-based gene drive systems. Given this context, discuss in a few sentences the likely mechanism by which a population becomes "resistant" to gene drive.

107. The following is from:

Kumar P, PK Rana, VK Singhal, H Singh, BS Kholia. 2018. Chromosome count, meiotic abnormalities and pollen sterility in Lahaul sweetvetch (*Hedysarum astragaloides* Benth. ex Baker, Fabaceae), an endemic and threatened species from India.

The plant is 2n = 2x = 14, and is shown at right. In the photo below, the bar = 10 µm.



A) What is photo I of, and what are the diagnostic features that allow you to make that determination?

B) Provide an interpretative diagram of what each arrow is pointing at.

108. The following is from:

Rouiss H, J Cuenca, L Navarro, P Ollitrault, and P Aleza. 2017. Unreduced megagametophyte production in lemon occurs via three meiotic mechanisms, predominantly < -- > Division Restitution. Front. Plant Sci., doi.org/10.3389/fpls.2017.01211

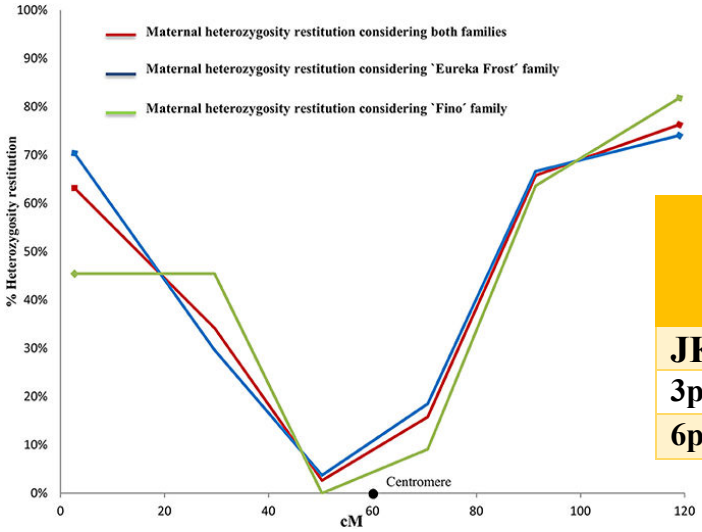
In this paper, "Triploid and tetraploid citrus hybrids were obtained via 2x X 2x and 2x X 4x sexual hybridizations using diploid "Eureka Frost" and "Fino" lemon genotypes as female parents pollinated with diploid "Fortune" mandarin (*C. clementina* x *C. tangerina*) and *C. ichangensis* Swing and tetraploid *C. macrophylla*." The resulting progeny were genotyped with both SSR and SNP markers to determine if they were homozygous or heterozygous. These markers were then placed on the reference clementine genetic map.

Based on the figure below, answer these questions **and explain how you arrived at your answer in each case:**

A) What is the mode of 2n egg production in Fino and Eureka Frost?

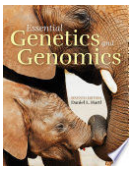
B) Is the centromere correctly positioned in the clementine reference genetic map?

C) Calculate the marker-centromere distance for the markers below:



Marker	# *heterozygous* progeny	Distance from c-mere
JK-CAC15	5/20	
3p 11355960	2/20	
6p 7496245	0/20	

109. The following was taken from:



Essential Genetics and Genomics
By Daniel L. Hartl

7th Edition

http://samples.jbpub.com/9781449686888/86482_CH04_111_151.pdf

lazy (*lz*) WT *waxy* (*wx*) *sugary* (*su*) kernels (shriveled) next to WT

Photo credit: Dong et al., 2013. Genes, Development, and Evolution., Liu et al., 2009. Genetics. *su* image source unknown.

The genetic distance between three loci was determined by initially producing an F_1 with the genotype:

Lz/lz; Gl/gl; Su/su

Genotype of gamete from hybrid parent	**Number of progeny**
Lz Gl Su	286
lz Gl Su	33
Lz gl Su	59
Lz Gl su	4
lz gl Su	2
lz Gl su	44
Lz gl su	40
lz gl su	272
Total Number	**740**

This F_1 was then test crossed to an individual homozygous recessive for all three loci. The table below shows the progeny classes that were obtained.

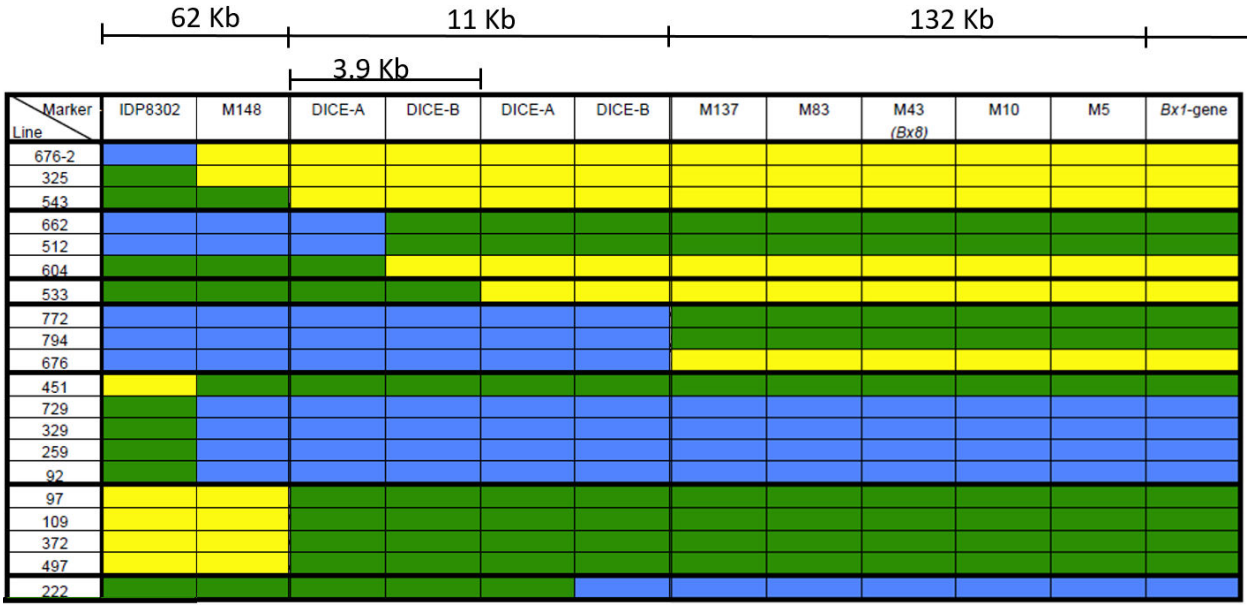
A) Create a genetic map for these three loci.

B) For the two furthest markers, determine if interference has occurred and if so, in which direction. Interference = 1 – 0.52 = 48%

Use the reverse side of this sheet for your calculations

110. T**he following is modified from:**

Zeng LL, MD McMullen, E Bauer, CC Schoen, A Gierl, and M. Frey. 2015. J. Exp. Botany 66:3917-3930.



Marker / Line	IDP8302	M148	DICE-A	DICE-B	DICE-A	DICE-B	M137	M83	M43 (Bx8)	M10	M5	*Bx1*-gene
676-2												
325												
543												
662												
512												
604												
533												
772												
794												
676												
451												
729												
329												
259												
92												
97												
109												
372												
497												
222												

Zeng et al. (2015) screened 750 plants in a maize BC1 population for crossovers. 20 individuals (shown in rows) showed a crossover in this region of interest. The color of the column indicates the genotype for each marker (columns) where yellow is B73, blue is Mo17, and green is heterozygous. Physical distances are listed at the top

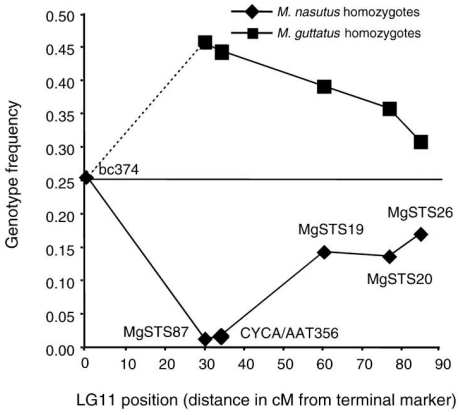
A) Calculate the genetic distance between IDP8302 and M137.

B) Calculate the recombination rate in cM / Mb between IDP8302 and M137.

C) The average genome-wide recombination rate in maize varies between 0.8 to 1.3 cM / Mb. How does the recombination rate between IDP8302 and M137 compare? Regarding recombination, how would you describe & categorize this region?

103. The following is from:

Fishman, L. and Willis, J.H. 2005. Genetics 169(1): 347-353.
Fishman, L. and Saunders, A. 2008. Science 322(5907): 1559-1562.



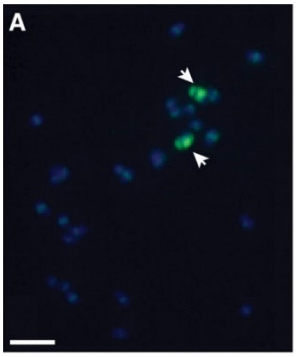
Here, Fishman & Willis (2005) counted the number of individuals in an F_2 population from *Mimulus nasutus* and *M. guttatus* that were homozygous for markers from one parent or the other. The markers had previously been mapped on linkage group 11.

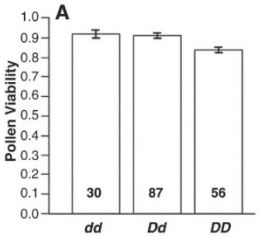
Mimulus guttatus. Source: crocus.co.uk

A) What genetic phenomenon is going on here and which parent is benefiting from it?

B) Maximal/minimal genotype frequencies occur at the MgSTS87 marker but these frequencies are lower/higher (respectively) than all other markers on LG11. What is the reason for this discrepancy?

C) The fluorescence micrograph image shows FISH in *M. guttatus* where green represents a centromeric probe. The arrows point to giant centromeres that are genetically linked to MgSTS87. This centromere is <u>much</u> larger than all others observed in either of the two parents, including the *M. nasutus* centromere on the corresponding chromosome. Note the other centromeres are so small they are barely visible with the FISH probe. Propose a <u>simple cytological mechanism</u> to explain the genetic phenomenon described in part A of this question.

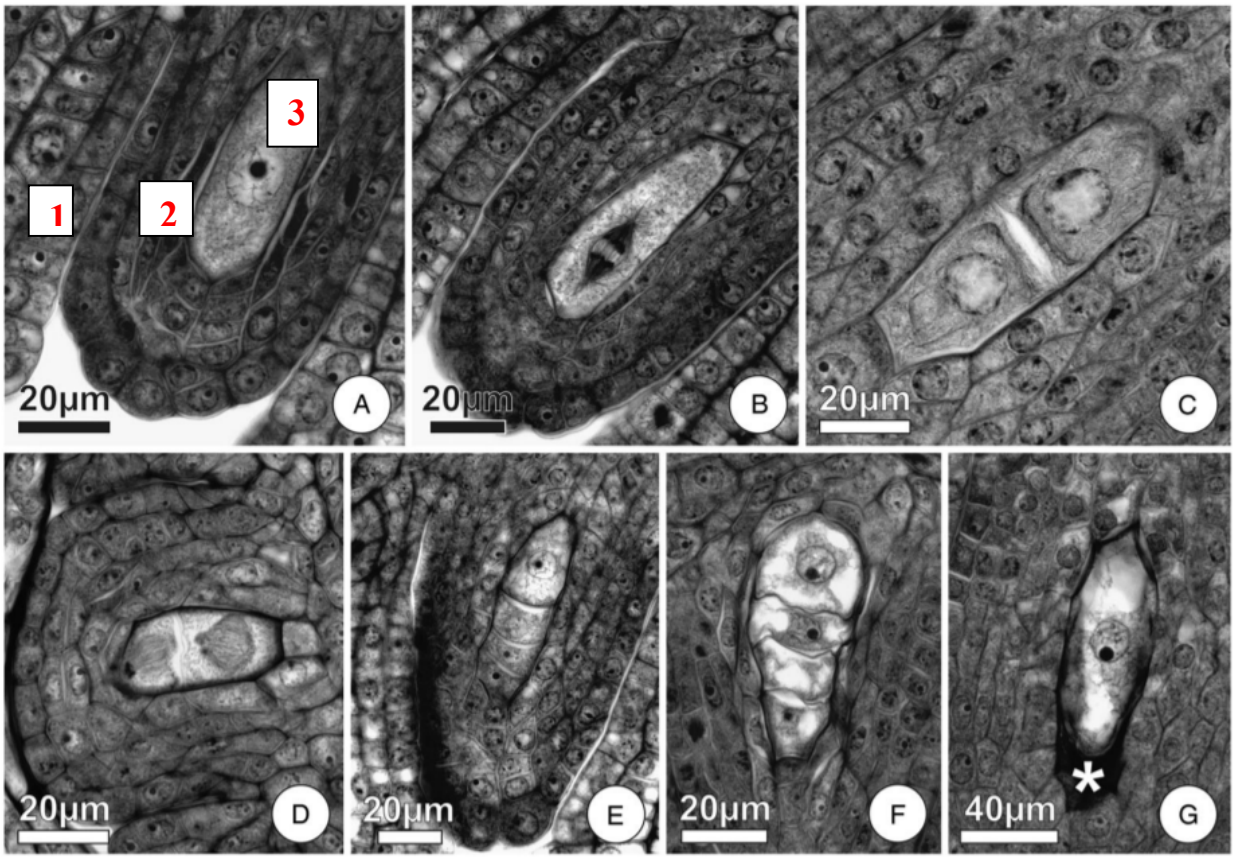




MgSTS87 was fine-mapped to a locus renamed *D* where *D* is the *M. guttatus* allele and *d* represents the *M. nasutus* allele. Explain a possible reason why *DD* has a lower pollen viability?

112. The following is from:

Galastri NA, DM Trombert Oliveira. 2016. _____ and _____ in species of Annonaceae, the largest family of early-diverging angiosperms. New Zealand J of Botany 54: 63-73



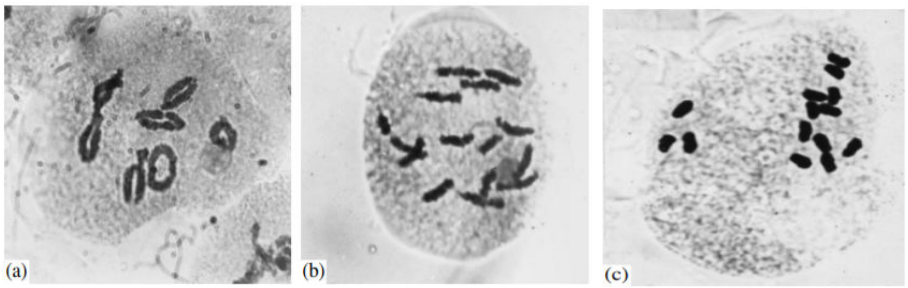
A. The process shown in Figs A – G is called _____

B. Label what is shown by 1, 2, and 3 in figure A

C. For figures A, C and G, give ____ n = _____ C = _____ X that the largest cell in the figure would have.

113. The following is from:

Sonikhina SP et al. 2001. Genetic control of chromosome synapsis at meiosis in rye *Secale cereale* L.: The *sy19* gene controlling heterologous synapsis. Russian J of Genetics 37: 71-79.

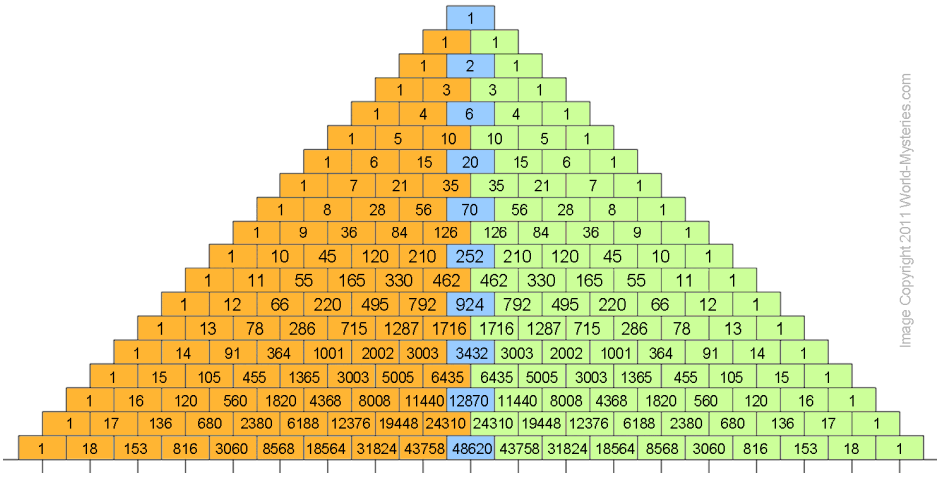


Prophase in normal (L) and sy19 sy19 individuals (R)

Anaphase I in sy19 sy19 mutants

A) What % of pollen grains can be expected to be fertile?

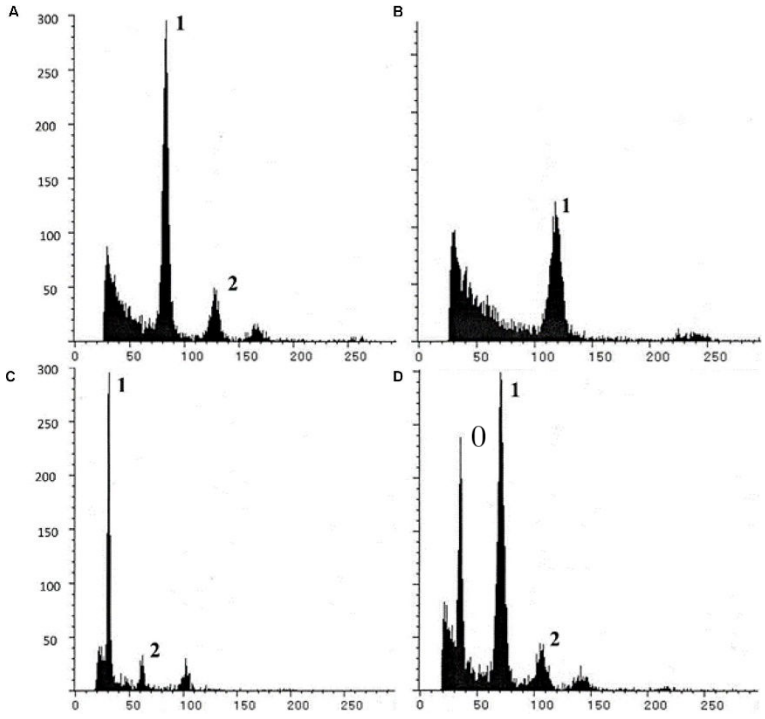
B) What % of Ana I will show a disjunction with the same numbers as seen in (C)? Show your work



114. Extra credit question

The following is from:
Kaushal et al, 2019. Partitioning apomixis components to understand and utilize gametophytic apomixis. Frontiers in Plant Science, https://doi.org/10.3389/fpls.2019.00256

In panel A, peak 1 is from a zygotic embryo, and peak 2 is from the endosperm. Based on that, what is the ploidy of the numbered peaks in panels A, B, C, and D?



Name a method/process discussed in class that would give you a plant with the ploidy illustrated by peak 0 in panel D.