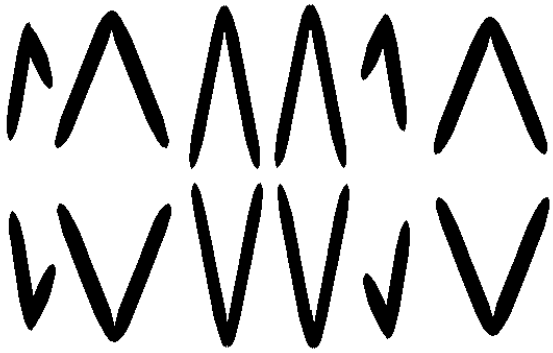
1. You are shown the cell diagramed at right and given no other information. Indicate two different possible stages of cell division which could be depicted and also answer the following questions based upon this diagram.



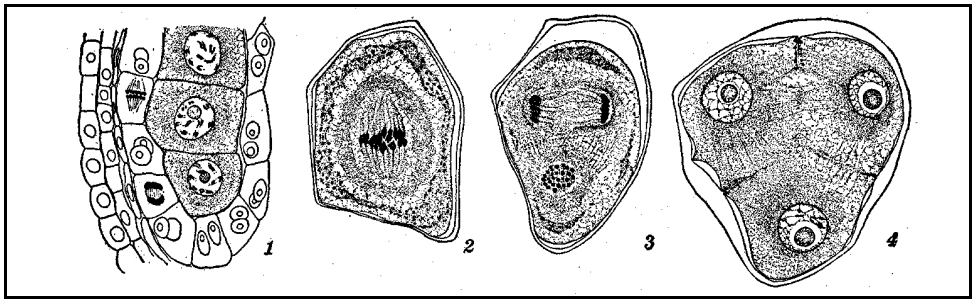
A B

	A	B
Stage of division: (be specific)	Anaphase of mitosis	Anaphase II
n =	_____	_____
x =	_____	_____

Note: x could have two different values for one of the possible stages. Indicate both values.

In the beginning of the interphase immediately after this division, for each daughter cell, c =	_____	_____

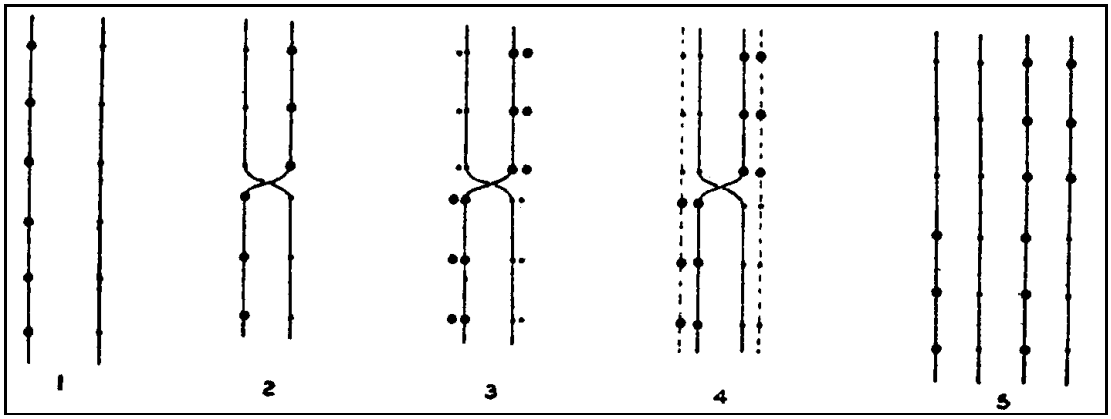
2. For the diagrams at right, identify:



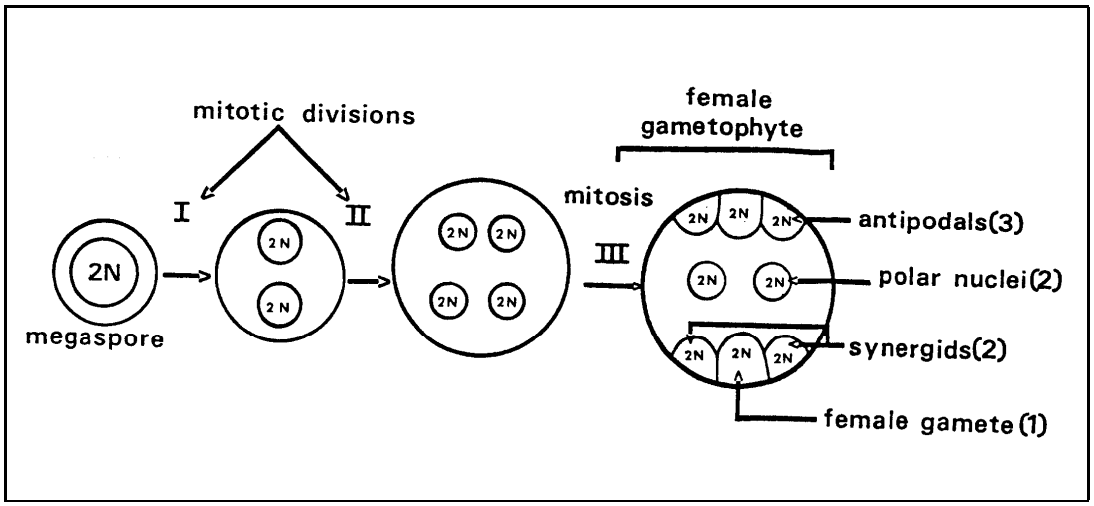
A) The process that is taking place.
B) The type of plant that this is taking place in.
C) The names of the four individual stages illustrated.

3. Completely describe a set of procedures or experiments you could do to prove that independent assortment is taking place. However, instead of using a microscope and grasshoppers like Carothers did, you are to use a flow cytometer, and the plant species of your choice.

4. The diagram below depicts the copy-choice model of crossing over, as proposed by Belling. In this model, chromosomes cross over, then DNA replication takes place. Explain why this model is not acceptable.



5. The following diagram was handed out in one of the undergraduate classes taught on this campus, explaining how megagametogenesis normally occurs:



a) Do you agree with the way this diagram is labeled? If yes, explain why. If no, explain why and correct the diagram accordingly.

b) Suppose the intent of the instructor was to denote that the sporophyte producing this megaspore was a tetraploid. Now, given this information, do you agree with the way this diagram is labeled? If yes, explain why. If no, explain why and correct the diagram accordingly.

6. Fill out the following table:

Species	Reference	Genotype	% recombination observed between:			Coefficient of Coincidence	% Interference
			1st & 2nd genes= exp DCO	2nd & 3rd genes= exp DCO	1st & 3rd genes= obs DCO		
Zea mays	Hutchison, 1922	*C sh Wx* H *c Sh wx*	3.4	18.3	0.1		
♀ *Primula sinensis*	de Winton & Haldane, 1935	*S B G* H *s b g*	6.6	32.1	1.7		
♂ *Primula sinensis*	de Winton & Haldane, 1935	*S B G* H *s b g*	11.6	35.0	0.77		
Lycopersicon esculentum	Sansome, 1933	*D P O* H *d p o*	2.9	14.3	0.0		

Coefficient of Coincidence Interference

Zea mays:

Primula

% *Primula*

Lycopersicon

b) Is the difference in recombination between male and female *Primula* expected? Why or why not.

7. Assume you have a plant with XYz on one chromosome and xyZ on its homologue. There is a 4% recombination between X and Y, and 10% between Y and Z. What are the expected frequencies of gametes with

A) No interference
B) Coincidence of 0.25

Gametes:	No interference:	Coincidence of 0.25 (Interference = 1-0.25=0.750

Parental types:
XYz
xyZ

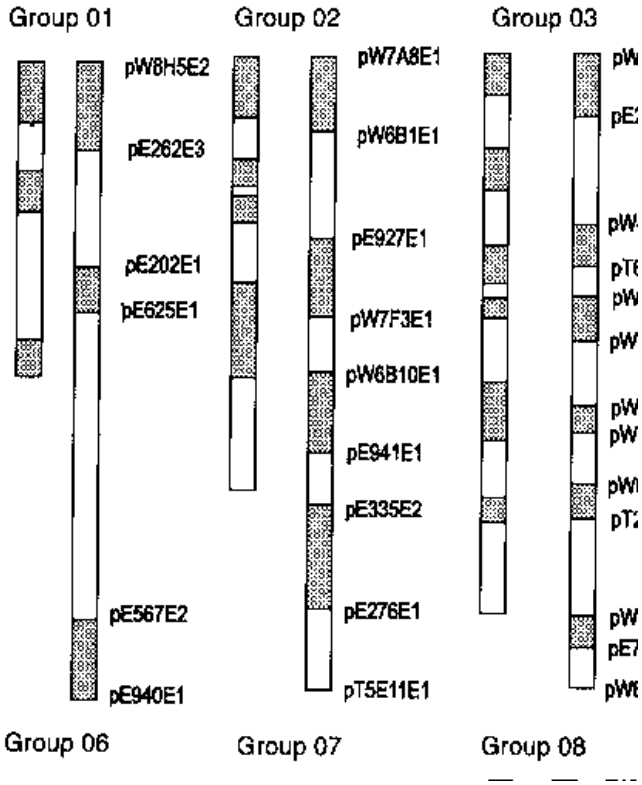
Single crossover types:
xYz
XyZ
XYZ
xyz

Double crossover types:
Xyz
xYZ

9. The following is a set of paired ideotypes of *Brassica oleracea* from:

Kearsey, MJ, LD Ramsay, DE Jennings, DJ Lydiate, EJR Bohuon, and DF Marshall. 1996. Theor. Appl. Genet. 92:363-367.

For each linkage group, bars on the left reflect recombination distances in the BC_1 generation; those on the right reflect those from the BC_2 generation. The population was derived by crossing *B. oleracea* cv. Green Duke with *B. oleracea* var *alboglabra*. The F_1, used as the pollen parent, was backcrossed to the *alboglabra* parent, to generate the BC_1 map shown below. Then, the BC_1 plants were then used as a female parent, and pollinated with *alboglabra* pollen to generate the BC_2 map below:

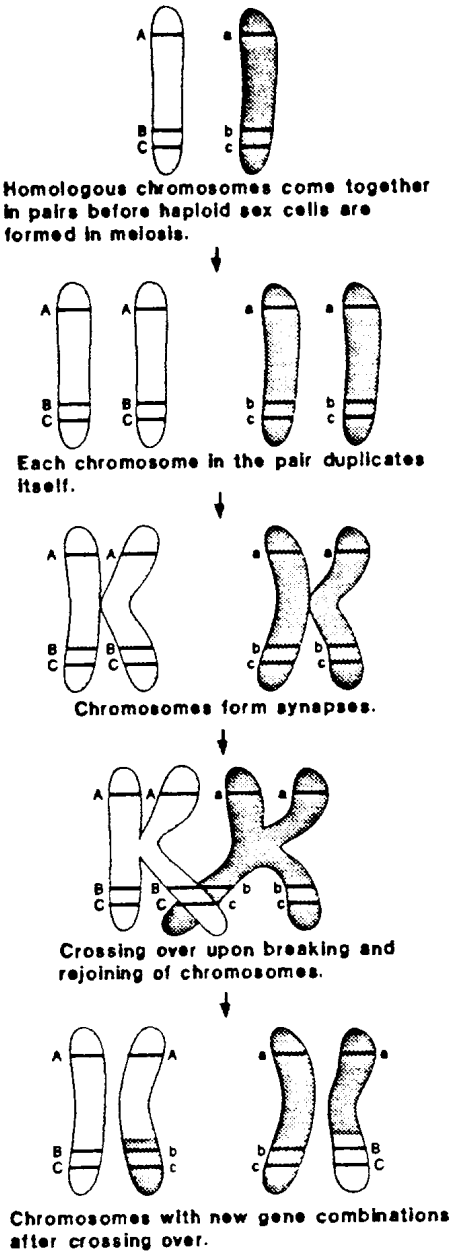


Notice that the BC_2 map is 66% longer than the BC_1 map, reflecting differences in recombination between the two populations. Describe the 3 most likely factors that account for this. Do not exceed the back of this page for your answer.

10. The diagram at right was produced by the Office of Technology Assessment, the government agency responsible for explaining scientific issues to congress and providing advice on scientific matters. Correct the mistakes in the diagram.

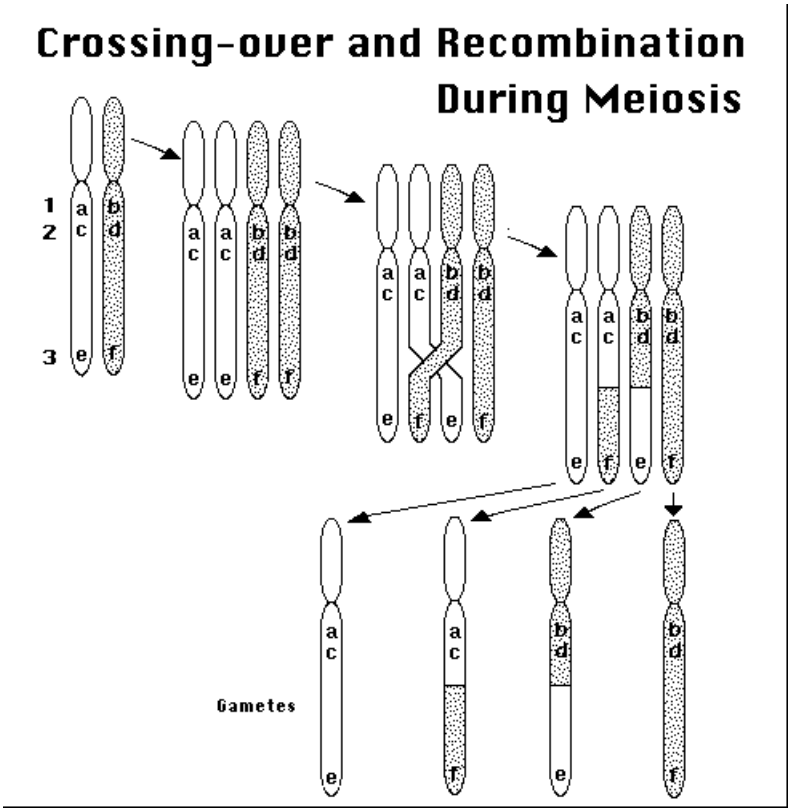
PSB this office was the victim of budget cuts during the recent Republican takeover of congress, and no longer exists.

Figure 2-5.—Separation of Linked Genes by Crossing Over of Chromosomes During Meiosis



SOURCE: Office of Technology Assessment, 1988.

11. This diagram is found in the Genentech web page, titled AAccess excellence@, the purpose of which is to provide a teaching resource for teachers. Please correct this diagram. (http://www.gene.com/ae/AB/GG/comeiosis.html):



12. A mutation is known in alfalfa (2n = 4x = 32) in which no cytokinesis takes place after meiosis II of microsporogenesis (Pfeiffer and Bingham, 1983; Can. J. Genet. Cytogenet. 25:107-112):

a) What is the ploidy of the microspores formed, and the terminology used to describe them?

b) Would it also matter if this plant was a synaptic mutant? Why or why not?

b) If alfalfa was a monocot instead of a dicot, would the ploidy, genotype, or viability of the spores be any different?

c) F = 1/7 =

13. The following data are from:

Allendorf, F.W., J.E. Seeb, K.L. Knudsen, G.H. Thorgaard, and R.F. Leary. 1986. Gene-centromere mapping of 25 loci in rainbow trout. J. Hered. 77:307-312.

In fish, heat shock can be used to prevent the second meiotic division during egg formation, resulting in the formation of 2n eggs. If the resulting eggs are then exposed to UV-irradiated sperm, then the eggs will develop into fish without being actually fertilized.

In this case, the mother fish was heterozygous for various allozymes, and resulting progeny fish were analyzed to determine whether they were homozygous or heterozygous for each allele. Results are as follows:

Enzyme	Homozygotes for first allele	Heterozygotes	Homozygotes for second allele	Gene-Centromere Distance
Aco2	49	172	49	
Hex	98	7	102	
Me2	3	110	1	

A. When referring to 2n gametes, distinguish between the terms mode and mechanism.

.

B. What is the mode of 2n egg formation in this example?

C. Determine the gene-centromere distance in each case. Keep in mind that here you are sampling the gametes directly, whereas in class you were inferring the gametic genotype based on progeny phenotype. *Hint*: In this case, the alleles are codominant, as opposed to the dominant:recessive example from class. Think of one of the alleles as recessive, and then it plugs into the formulae from class.

14. A monoploid (2n=1x=8) peach plant was identified that, instead of being sterile, produced 1x

pollen [Hesse, C.O. 1971. Monoploid peaches, *Prunus persica* Batch: Description and meiotic analysis. J. Amer. Soc. Hort. Sci. 96:326-330.].

A) Diagram the events of meiosis with a mechanism that can account for this phenomenon.

B) Without any special mechanism to restore fertility, what would be the frequency of fertile haploid pollen formation due to chance alone.

15. Wagenvoort, M., and E. Zimnoch-Guzowska. 1992. Gene-centromere mapping in potato by half-tetrad analysis: map distances of H_1, *Rx*, and *Ry*, and their possible use for ascertaining the mode of 2*n* pollen formation. Genome 35:1-7.

			Progeny				Map
Gene	Cross		Resistant	Susceptible	% suscept.	Mode	Distance
H_1	H_1h_1 H	$h_1h_1h_1h_1$	128	65	33.7	SDR	16.3
Rx	*Rxrx* H	*rxrxrxrx*	229	44	16.1	Either	33.0
Ry	*Ryry* H	*ryryryry*	34	19	35.8	SDR	14.2

In this case, H_1 gives resistance to *Globodera rostochiensis*; *Rx* gives resistance to potato virus X; and *Ry* gives resistance to potato virus Y. Based on the data provided, give the gene-centromere distance for each gene, and indicate the mode of 2n gamete formation.

For SDR: 50% -% nulliplex
For FDR: % recessive H 2

H1 if SDR:
if FDR:

Rx if SDR:
if FDR:

Ry if SDR:
if FDR:

16. Following is the abstract from:

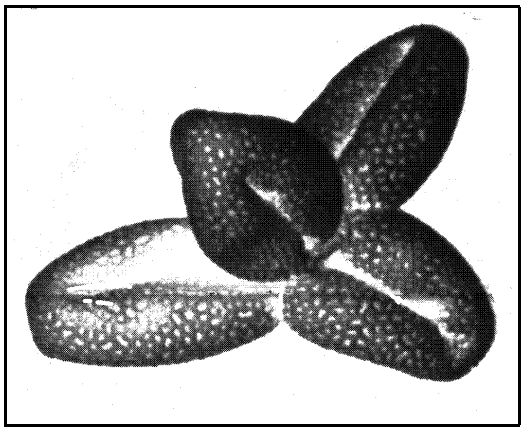
Camadro, E.L. 1992. Cytological mechanism of 2n microspore formation in garden asparagus. HortScience 27:831-832.

> Microsporogenesis was studied in 42 randomly chosen F_2 plants of garden asparagus (*Asparagus officinalis* L. cv. UC 157) (2n = 2x = 20) that had been previously screened for production of pollen of heterogenous size. At the tetrad stage, the average frequencies of tetrads, triads, and dyads were 58.9%, 15.4%, and 25.9%, respectively. *Dyads and triads originated from the lack of chromosome migration toward opposite poles at anaphase II* in either one or both cells of a microsporocyte, followed by the absence of cytokinesis in telophase II.

A) Based on the description in the abstract, what is the MODE of 2n gamete formation?

B) Based on the description in the abstract, is asparagus a monocot or a dicot

17. The adjacent photo is from:



Preuss, D., Rhee, S.Y., and Davis, R.W. 1994. Tetrad analysis possible in *Arabidopsis* with mutation of the *QUARTET* (*QRT*) genes. Science. 264:1458-1460.

In this article, the authors describe a mutation of arabidopsis in which the microspores do not fall apart, and remain as in their telophase II configuration.

a) If you did not know anything else about this plant, explain how you would determine, based on the photo, whether this plant was a dicot or a monocot.

b) Explain how you would use this mutant to prove that crossing over takes place at the 4-strand stage.

18. In the following paper:

Werner, J.E., D.S. Douches, and R. Freyre. 1992. Use of half-tetrad analysis to discriminate between two types of 2n egg formation in a potato haploid. Genome 35:741-745.

The authors used 2x-4x crosses and found the distance between the centromere and the *Mdh-1* gene to be 21.6 cM. Previous results in other potatoes, using the reciprocal cross (4x-2x) had found the distance to be 33.5 cM. Discuss 4 factors that can account for the difference in results.

19. In the paper, "Frequency and stability of tetraploids from 2X-4X crosses in red clover" (1983; Crop Sci. 23:1191-1194), the authors make the following statement:

> "The unreduced-gamete method of chromosome doubling involves doubling of reproductive tissue and is apparently the mechanism most prevalent in nature....Nitrous-oxide induced doubling also may be an example of reproductive tissue treatment in that the first division of the zygote is arrested and chromosome numbers are subsequently multiplied."

The authors' premise throughout the paper is that doubling the chromosome number of a plant using nitrous oxide (which works like colchicine on the zygote) gives the same results, genetically speaking, that using 2n gametes (type of 2n gamete is not mentioned) would give.)Do you agree with the authors? Explain your answer.

20. In the following paper:

Qu, L. and JF Hancock. 1995. Nature of 2n gamete formation and mode of inheritance in interspecific hybrids of diploid *Vaccinium darrowi* and tetraploid *V. corymbosum*. Theor. Appl. Genet. 91:1309-1315.

the authors crossed a 4x blueberry, *Vaccinium corymbosum* cv Bluecrop with 2x *V. darrowi* cv Florida 4B, to get a new 4x genotype, cv US 75. Molecular analysis revealed that 70% of the heterozygosity from Florida 4B was present in US 75.

Based on this information, what was the most likely mode of 2n pollen formation?

FDR- Only FDR can explain such high heterozygosity

Is 70% the value you would have expected to find in US 75? If yes, explain why. If not, explain possible reasons for the discrepancy.

The frequency is below expectations. The major reasons could be:

22. The diagram below was copied from the paper "Mechanisms and genetic implications of 2n-gamete formation", by J.G.T. Hermsen (1984; Iowa State J. Res. 58(4):421-434). Make the necessary correction(s) on the diagram.

● = centromere
X = crossover

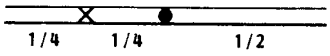
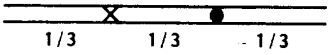
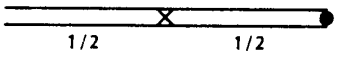
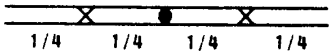
Type of chromosome	Percentage of parental hyterozygosity	
	in FDR-gametes	in SDR-gametes
 1/4 1/4 1/2	3/4 · 1 + 1/4 · 1/2 = 7/8	3/4 · 0 + 1/4 · 1 = 1/4
 1/3 1/3 1/3	2/3 · 1 + 1/3 · 1/2 = 5/6	2/3 · 0 + 1/3 · 1 = 1/3
 1/2 1/2	1/2 · 1 + 1/2 · 1/2 = 3/4	1/2 · 0 + 1/2 · 1 = 1/2
 1/4 1/4 1/4 1/4	2/4 · 1 + 2/4 · 1/2 = 3/4	2/4 · 0 + 2/4 · 1 = 1/2
Average	80.2%	39.6%

Table 1. Percentage of the parental heterozygosity present in FDR- and SDR-gametes for four types of chromosome.

23. The following information is from:

Tavoletti, S. 1994. Cytological mechanisms of 2n egg formation in a diploid genotype of *Medicago sativa* subsp. *falcata*. Euphytica 78:1-8.

In this paper, the author used ovule clearing to examine the cytology of 2n egg production in one genotype of alfalfa. He found two mechanisms: a) absence of the second meiotic division, and b) "apomeiosis" (a mechanism whereby a cell became an egg in the absence of meiosis).

Are these mechanisms FDR or SDR in mode? Why?

A)

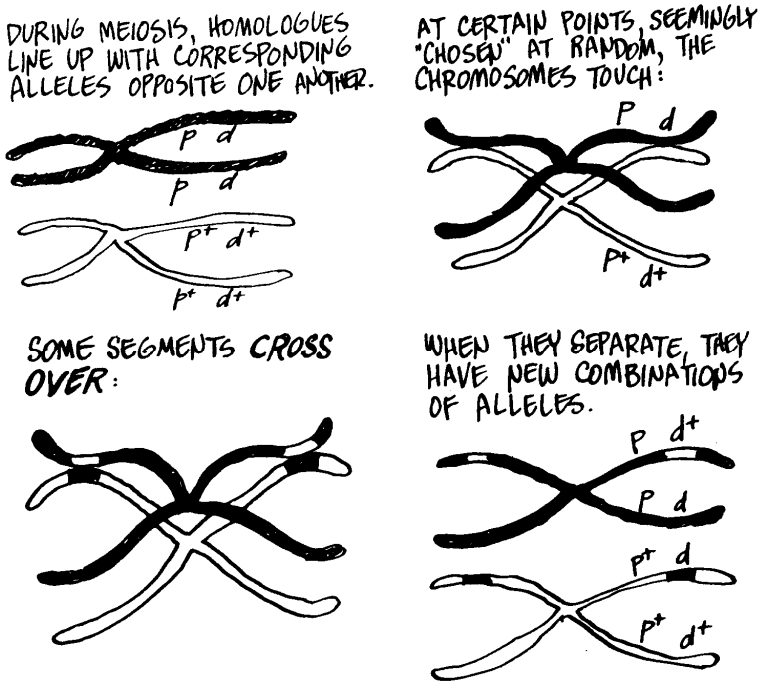
B)

Would any of these qualify as unreduced gametes?
Why doesn=t apomeiosis fall under the category of apomixis?

24. The diagram below is from:

Gonick, L., and M. Wheelis. 1991. Cartoon Guide to Genetics. Harper Perennial, New York.

Point out two major things wrong with the diagrams and/or the description.



25. In the following paper:

> Bastiaanssen, H.J.M., M.S. Ramana, Z. Sawor, M. Mincione, A.v.d. Steen, and E. Jacobsen. 1996. Pollen markers for gene-centromere mapping in diploid potato. Theor. Appl. Genet. 93:1040-1047.
>
> the authors were working with 3 potato genotypes, two of which produced 2n pollen via parallel spindle formation. These plants were heterozygous for the *amylose-free* locus (*amf*). Pollen grains with the recessive allele are easily distinguishable upon staining with iodine-potassium iodide, as pollen with the wild-type allele stains blue, while those with the recessive stain red. Data are as follows:

Plant	n pollen		2n pollen	
	blue	red	blue	red
HB93-7108-08	232	222	--	--
B92-7015-4	365	296	496	160 160/656=24.4%
RS93-8025-1	--	--	1305	93

> Notice that the first plant did not produce any 2n pollen, while the third plant was also a synaptic mutant.

A. Based on results from the second plant, what is the gene-centromere distance for the *amf* locus? Show your work!

B. Given that this plant produced both n and 2n pollen, what is the most likely method the authors used to identify pollen as either n or 2n?

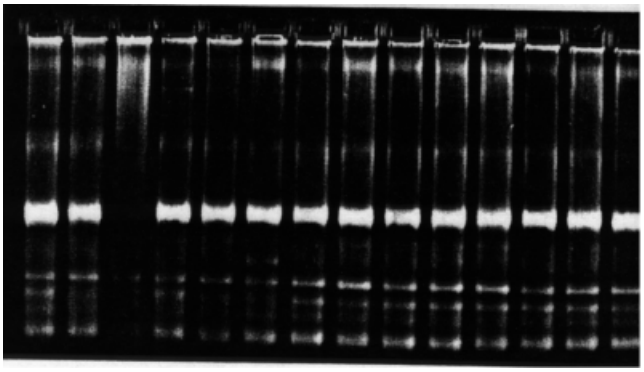
C. Explain why no viable n pollen grains were found for the third plant.

D. What is the gene-centromere distance, based on the results from the third plant?

E. Why is the distance in the third plant different from that based on the second plant?

26. In the following paper:

Kindinger, B. and C. Dewald. 1997. A system for genetic change in apomictic eastern gammagrass. Crop Sci. 36:250-255.



The authors looked at 100 progeny from an apomictic plant, and found a 4% incidence of changes. An example is illustrated at the right, where there is an absence of a RAPD band in lane 3.

Since only one band would change at a time, the changes could not be due to a stray sexual cross. Furthermore, the 4% rate of change is too high to represent the mutation rate. Given that the type of apomixis found in this plant is diplospory, name and describe the phenomenon which is most likely going on. Limit your description to two (2) sentences at most.

28. The following is from:

Krelke CM and WJ Stiekema. 1997. Reduced recombination and distorted segregation in a *Solanum tuberosum* (2x) H *S. spegazzinii* (2x) hybrid. Genome 40:180-187.

According to the authors, AIn this paper we describe the reduced recombination in an interspecific hybrid between *Solanum tuberosum* and *Solanum spegazzinii*. To study these phenomena, a cross was made between a (di)haploid [2n=2x] *S. tuberosum*, used as a female parent, and a diploid [2n=2x] wild potato species, *S. spegazzinii*, used as a male parent. Next, a backcross (BC) population was made with F_1 genotype 38 that was backcrossed to *S. tuberosum*. In the backcross, *S. tuberosum* was used as the male parent.@

Data are in the table at right. Name and *BRIEFLY* discuss two possible reasons that most likely explain the reduced recombination frequency observed in the hybrid map.

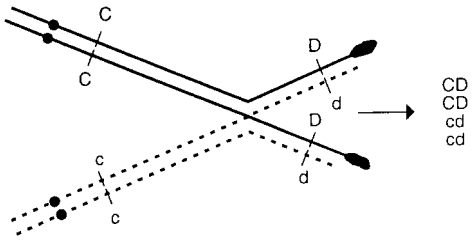
Limit your answer to 2 sentences

		Distance (cM)	
Chromosome	Interval	F_1-38 map	TBR map*
1	Ssp55-Ssp16 Ssp16-Ssp126a Ssp126a-Ssp56 Ssp56-Ssp30	10.0 26.8 32.7 32.5	22.6 65.2 29.3 24.7
2	Ssp103-Ssp 38	7.4	10.4
3	TG56-TG130	46.8	92.8
5	Ssp72-Ssp88 Ssp88-TG69	15.4 20.2	16.3 56.5
7	TG143-TG61 TG61-Ssp57	12.5 7.5	23.9 12.8
8	Ssp34-TG16	59.4	29.1
9	Ssp59-Ssp32	21.3	12.5
10	Ac46-Ssp106	19.7	50.9
12	TG68-Ssp129	18.4	24.7
Total:		330.6	471.7

* Refers to an intraspecific map of *Solanum tuberosum*

29. The following diagram is from the following paper:

Maguire, M.P. 1995. Is the synaptonemal complex a disjunction machine? J. Hered. 86:330-340.



The diagram is a reproduction of an incorrect diagram the author found elsewhere, and she uses it to make a point about the degree to which meiosis is not properly understood. The diagram represents a heteromorphic pair of homologues, with that drawn in the dark line having a knob at the end, and the dotted one not having a knob at the end.

A. Redraw the diagram as it should be.

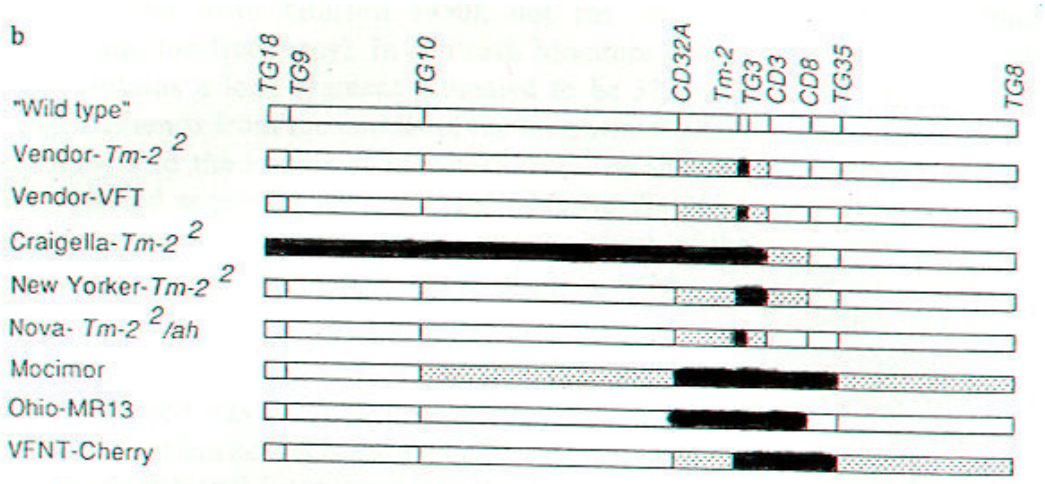
B. If you had insufficient background knowledge of meiosis to know if the diagram was correct or not, you could determine its correctness (or lack thereof) experimentally. Describe the cytogenetic stocks you would need and what to do with them in order to determine if the diagram was correct or not.

30. The following is from:

Young, ND and SD Tanksley. 1989. RFLP analysis of chromosomal segments retained around the *Tm-2* locus of tomato during backcross breeding. Theor. Appl. Genet. 77:353-359.

The *Tm*-2 gene originated in *Lycopersicon peruvianum* and has been backcrossed into several tomato cultivars, as it confers resistance to tobacco mosaic virus. It is located on chromosome 9. Backcross theory used to say that after a few backcrosses, all flanking DNA would be eliminated, and only the gene itself would be introgressed.

However, RFLP data from 8 tomato cultivars in this example show otherwise. In the following diagram, clear boxes represent tomato DNA, shaded boxes represent DNA from *L. peruvianum*, and stippled segments indicate a chromosomal region, flanked by RFLP markers, in which the crossover between tomato and *L. peruvianum* chromosomes took place.



Use your knowledge of meiosis to explain why so much *L. peruvianum* DNA has been retained.

Limit your answer to the remaining space on this page.

- The most likely explanation is that the tomato and the peruvianum chromosomes are not pairing sufficiently well for the cross overs to occur.

- There could also be a gene suppressing crossing over in the vicinity.