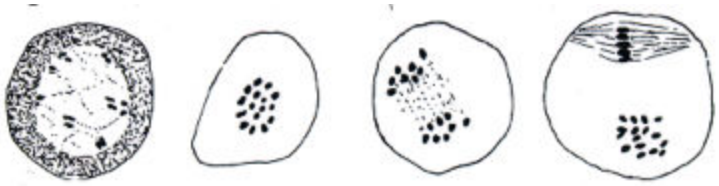
31. Answer this set of questions based on the following diagram. It is from:

A.G. Erith. 1924. White clover. A monograph. Duckworth & Co., London



A) The process collectively being shown by the 4 diagrams is:
B) Describe the key diagnostic features that led to your answer in A.

C) Name the 4 individual stages which are shown above.

D) Based on these diagrams, white clover is 2n = 2x = _____

E) Based on these diagrams, is white clover a monocot or a dicot? What is the key diagnostic feature which determines the answer?

F) Prior to the stage shown in the leftmost diagram, what were the coefficients for n, x, and c?

G) For the stage shown in the 2nd diagram, what are the coefficients for n, x, and c?

H) When the above process is all over, what will be the coefficients for n, x, and c for one of the resulting cells?

Do not exceed the allotted space for each answer.

32. The following information is from:

Hutchison, CB. 1922. The linkage of certain aleurone and endosperm factors in maize, and their relation to other linkage groups. Cornell Agr. Exp. Sta. Memoir 60.

Working with the following loci: *C* = colored endosperm; *c* = colorless
Sh = full kernels; *sh* = shrunken kernels
Wx = starchy kernels, *wx* = waxy kernels

Hutchison determined that the *C* locus was 3.5 map units from the *Sh* locus, which in turn was 18.3 map units from the *waxy* locus. He made a cross of colored-shrunken-starchy x colorless-full-waxy maize, the crossed the F_1 with maize that was colorless-shrunken-waxy. The kernel phenotypes and their respective numbers are below:

Parental types:
Colored-shrunken-starchy..... 2,538
Colorless-full-waxy 2,708

Single cross over types:
Colored-full-waxy 116
Colorless-shrunken-starchy 113

Colored-shrunken-waxy 601
Colorless-full-starchy 626

Double crossover types: .....
Colored-full-starchy 4
Colorless-shrunken-waxy 2

What is the amount of interference going on in this example?

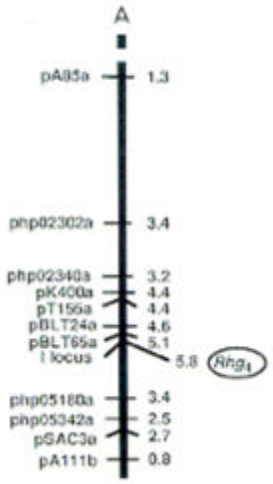
33. Pretend that you are a breeder trying to introgress apomixis from a wild relative into a crop. The objective is to replace F_1 hybrids with apomicts, thereby maintaining uniformity and heterosis. Furthermore, pretend that the crop you are working with has relatives which contain every possible type of apomixis. Discuss the relative abilities of adventitious embryony, apospory, diplospory to achieve the goals.

Limit your answer to 3 sentences

34. The adjacent figure shows a portion of the soybean linkage group A, and was taken from:

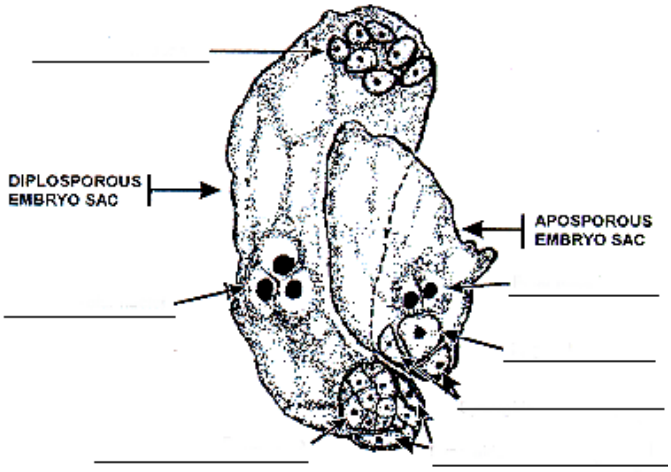
Webb, DM, BM Baltazar, AP Rao-Arelli, J Schupp, K Clayton, P Keim, and WD Beavis. 1995. Genetic mapping of soybean cyst nematode race-3 resistance loci in the soybean PI 437.654. Theor Appl Genet. 95:574-581.

As can be seen from the figure, the *i* gene for black seed coat in soybean is closely linked to the *Rgh*$_4$ gene for resistance to the cyst nematode. Hence, attempts to introgress cyst nematode resistance into soybean also resulted in the black seed coat trait being carried along. The problem with black seed coats is that the black color is due to anthocyanin in the seed coat. Upon crushing the soybeans for oil, the anthocyanin stains the oil, making it unsuitable to market. Breeders were finally able to break the linkage between these two traits by resorting to large numbers. Assume you had to once again break the linkage. List and BRIEFLY describe 3 things a breeder could do to derive a stock with an increased level of crossing over between these genes? Although many techniques to manipulate crossover frequencies were presented in class, not all are equally practical, and not all apply to all species. Thus, use common sense when choosing your answers.



35. The following is from:

Bonilla, JR and CL Quarin. 1997. Diplosporous and aposporous apomixis in a pentaploid race of *Paspalum minus*. Plant Sci. 127:97-104.



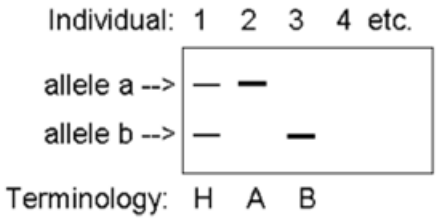
Paspalum minus is a small grass widely distributed from North America and the Greater Antilles to Paraguay and Bolivia in South America.

A) Label the structures which the arrows point to.

B) Based on the diagram, is this species pseudogamous or not? Be specific as to the particular detail of the diagram which answers this question.

36. The following is from:

Tavoletti, S., E.T. Bingham, B.S. Yandell, F. Veronesi, and T.C. Osborn. 1996. Half tetrad analysis in alfalfa using multiple restriction fragment length polymorphisms. Proc. Natl. Acad. Sci. USA 93: 10918-10922.



For this work, the authors used PG-F9, a diploid (2n=2x=16) clone of alfalfa which produces 2n eggs, and which is heterozygous for each of three RFLP markers [UWg119- MTSc9-UWg65] on linkage group one. For each RFLP marker, the large allele was designated as a, and the small allele as b.

PG-F9 was pollinated with MAG7, a tetraploid male whose RFLP alleles for the UWg119-MTSc9-UWg65 loci were distinguishable from those of PG-F9. Tetraploid progeny heterozygous for both markers from PG-F9 heterozygous for both alleles were designated as H, those homozygous for the large allele were designated as A, and those homozygous for the small allele were designated as B. Progeny data are as follows:

Genotypic composition at UWg119- MTSc9-UWg65	Number of progeny
AAA or BBB	91
AAH or BBH	30
AHH or BHH	12
HHH	7

A) Based on these results, what is the most likely mode of 2n egg formation? Explain (in the space provided) the basis for your answer.

B) Based on the above data, provide the genetic distance between the following chromosomal segments:

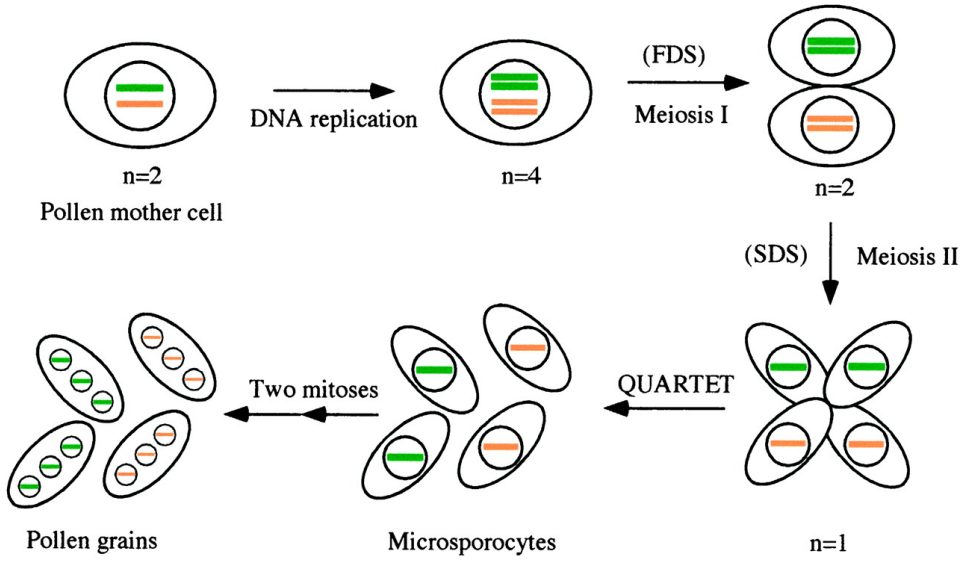
Interval	Genetic distance
Centromere -UWg119	
UWg119-MTSc9	
MTSc9-UWg65	

37. The following diagram is from:

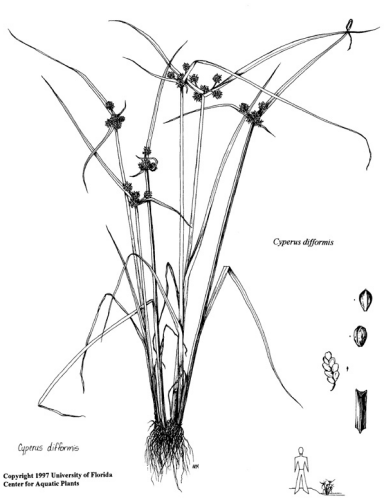
Copenhaver, G.P., K.C. Keith, and D. Preuss. 2000. Tetrad analysis in higher plants. A budding technology. Plant Physiol. 124:7-15.

In the diagram, FDS means first division separation, and SDS means second division separation.

Correct the n terminology used in this diagram, using n, x, and c. In addition, add centromeres in the appropriate places for the cells in the top row.



38. 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.



Many insects and some plants (sedges [in diagram], rushes, and some dodders) exhibit a phenomenon called >inverse meiosis= whereby the equational and reductional divisions occur in reverse order from standard meiosis. For an organism with 2n = 2x = 2, diagram inverse meiosis.

Assume the pair of homologues is isobrachial. Show one crossover per arm. Be sure and label the parts of the chromosome undergoing equational and reductional separations.

39.
Attached is a cartoon from the *Far Side* by Gary Larson

Notice the picture on the wall.

- Name the process illustrated by the picture
- Identify the 4 individual stages shown
- Provide the appropriate n, x, and c numbers for the first of the 4 cells shown here, and for one of the cells that will result from this process.

Note: Because the chromosomes are in three-dimensional space, not all can be seen in the second of the stages.

40. The following data are from:

Lindner, K.R., J.E. Seeb, C. Habicht, K.L. Knudsen, E. Kretschmer, D.J. Reedy, P. Spruell, and F.W. Allendorf. 2000. Gene-centromere mapping of 312 loci in pink salmon by half-tetrad analysis. Genome 43:538-549.

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 salmon was heterozygous for various microsatellite loci, and resulting progeny fish were analyzed to determine whether they were homozygous or heterozygous for each allele. Results are as follows:

Marker	Homozygotes for first allele	Heterozygotes	Homozygotes for second allele	Gene-Centromere Distance
OGO1c	86	40	88	
OGO4	11	206	9	
OTS1	123	88	117	
μSAT60-1	28	70	23	

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

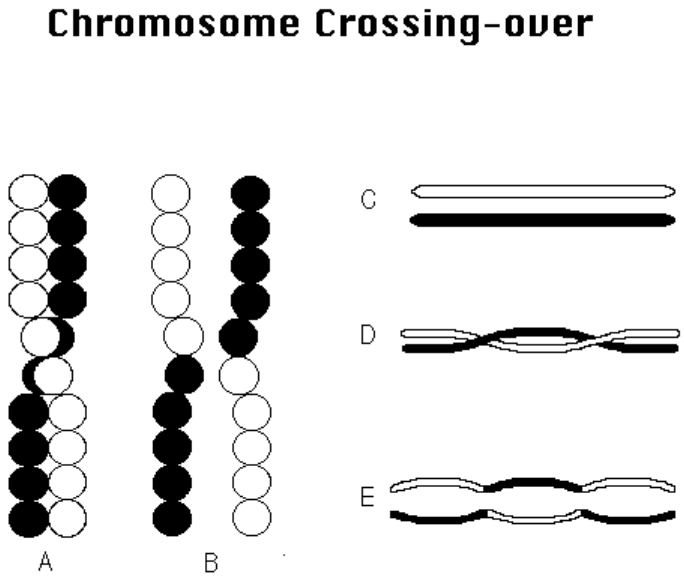
B. What is the mechanism of 2n egg formation in this example?

C. Determine the gene-centromere distance in each case.

41. The following diagram is from AAccess Excellence@ a set of Web pages to provide a resource for teachers. This particular diagram was found at http://www.gene.com/ae/AB/GG/chromosome.html, where it has been posted for the past few years until its removal within the past month. It was adapted from:

Morgan T.H., A.H. Sturtevant, H.J. Muller, and C.B. Bridges. 1915. The Mechanism of Mendelian Heredity. Henry Holt and Company, p 60 and 62.

Whereas this diagram was viable in 1915, it is now 2005.



Update the diagram as necessary. You only need to update the part on single cross over (ie, A & B).

A & B. Diagram to represent crossing over. At the level where the black and white rod cross in A, they fuse and unite as shown in B.

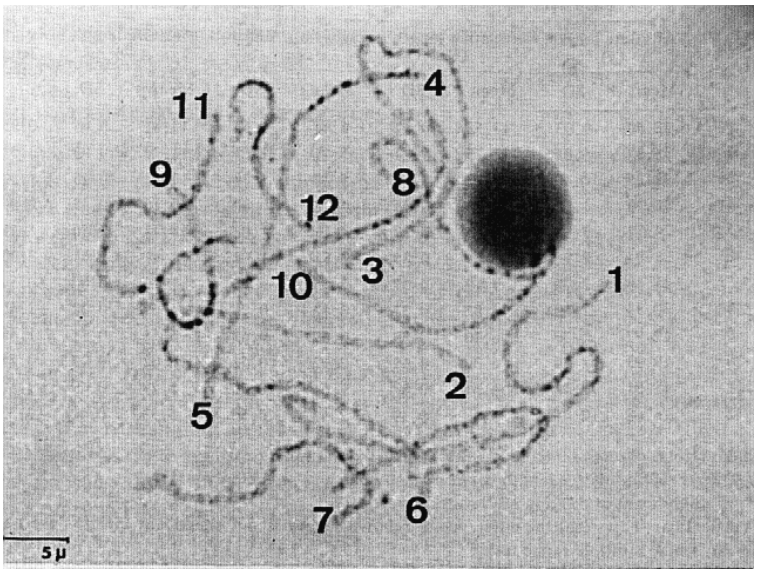
C-D. Diagram to illustrate double crossing over. The white and the black rods (C) twist and cross at two points. Where they cross they are represented as uniting (shown in E)

42. The following is from Gramene.org.

It is a rice (2n = 2x = 24) cell.

A) Name the stage this cell is in, and,

B) describe the diagnostic features used to arrive at that determination.



43. The following is from:

Jackson, R.C., N. Ngo, and H. Ngo. 2002. Am. J. Bot. 89:777-782.

This paper deals with *Haplopappus gracilis*, which is popular for cytogenetic studies, since it is 2n = 2x = 4. At right is a photo from a root-tip cell of this eudicot.

The next photo is of metaphase I of this same individual plant.

A). Is this what you would expect to see? Explain why or why not.

B) Calculate the probability that a fertile pollen grain will be formed at the end of meiosis.

44. The following is from:

Pickering, R.A., S. Hudakova, A. Houben, P.A. Johnston, and R.C. Butler. 2004. Theor. Appl. Genet. 109:911-916.

Hordeum bulbosum is a wild relative of barley (*H. vulgare)* , that has served as a source of several disease resistance genes. In this study, the authors looked at chiasma formation between chromosomes of *H. bulbosum* and *H. vulgare* in F_1 hybrids. Data are as follows:

Percent of chromosomal configurations found as:

Chromosome	2I present	Rod bivalent -long arm with long arm	Rod bivalent- short arm with short arm	Ring bivalent
1H-1H	7	62	0	31
2H-2H	0	15	2	83
4H-4H	2	22	9	66
5H-5H	6	63	3	28
6H-6H	2	30	10	58

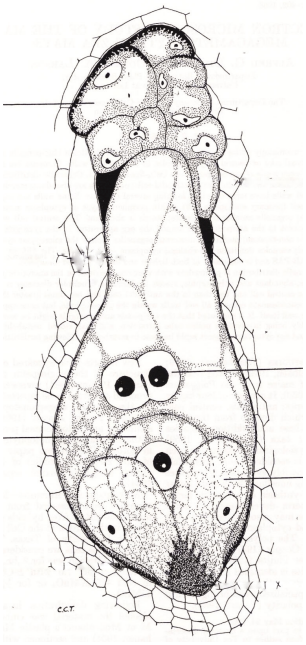
Just to clarify the terminology, 2I present means the homologues did not pair. Rod bivalent means there is only 1 crossover per chromosome pair. Ring bivalent means one crossover per arm.

In general, does it matter if the gene from *H. bulbosum* that needs to be bred into barley is located on the short arm or long arm of its respective chromosome? Explain your answer.

45. The following is from:

Diboll, A.G. and D.A. Larson. 1966. An electron microscopic study of the mature megagametophyte in *Zea mays*. Amer. J. Bot. 53:391-402.

Label the parts that have a line drawn to them.



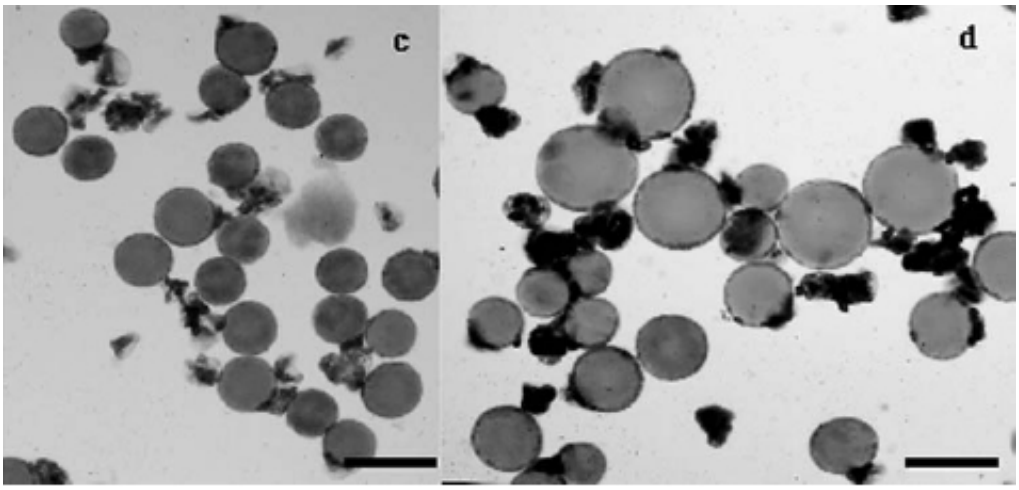
46. The following is from:

Okazaki, K., K. Kurimoto, I. Miyajima, A. Enami, H. Mizuochi, Y. Matusumoto, and H. Ohya. 2005. Euphytica 143:101-114.

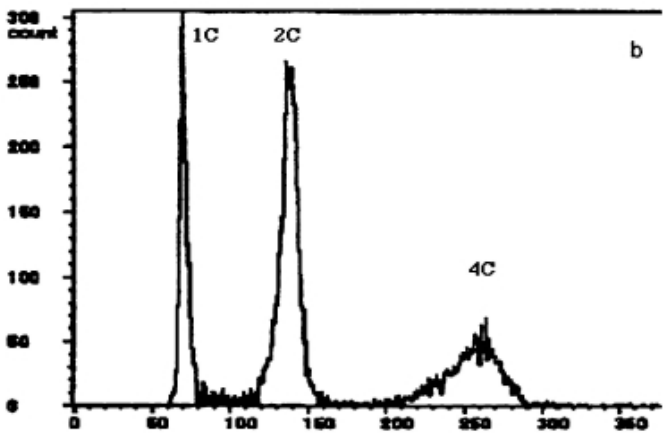
Panel c of the histogram at right shows the size distribution of pollen from untreated tulip (average diameter = 75 Φm), and panel d shows pollen from a plant treated with nitrous oxide.

Photo (c) below is pollen from an untreated tulip, while photo(d) is from a tulip treated with nitrous oxide, a c-mitotic agent.

At the bottom are DNA C measurements from a flow cytometer.



Draw a line connecting EACH peak from the flow cytometer to 2 pollen grains in photo (d) that would correspond to that peak. There should be a total of 6 lines drawn.



47. The following is from http://images.iasprr.org/

It is telophase I of microsporogenesis. Based on the photo:

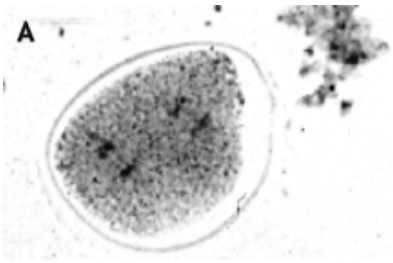
A) Is this a monocot or eudicot? What is the diagnostic feature you used to make this determination?

B) What type of tetrad will be formed at the end of telophase II?

48. The following is from:

Becerra Lopez-Lavelle, L.A. and G. Orjeda. 2002. J. Hered. 93:185-192.

Below is a photo of a meiocyte at Anaphase II, of a particular genotype of sweet potato, a dicot species.



A. Draw arrows along the axes of the spindles, and draw a line where cytokinesis will take place.

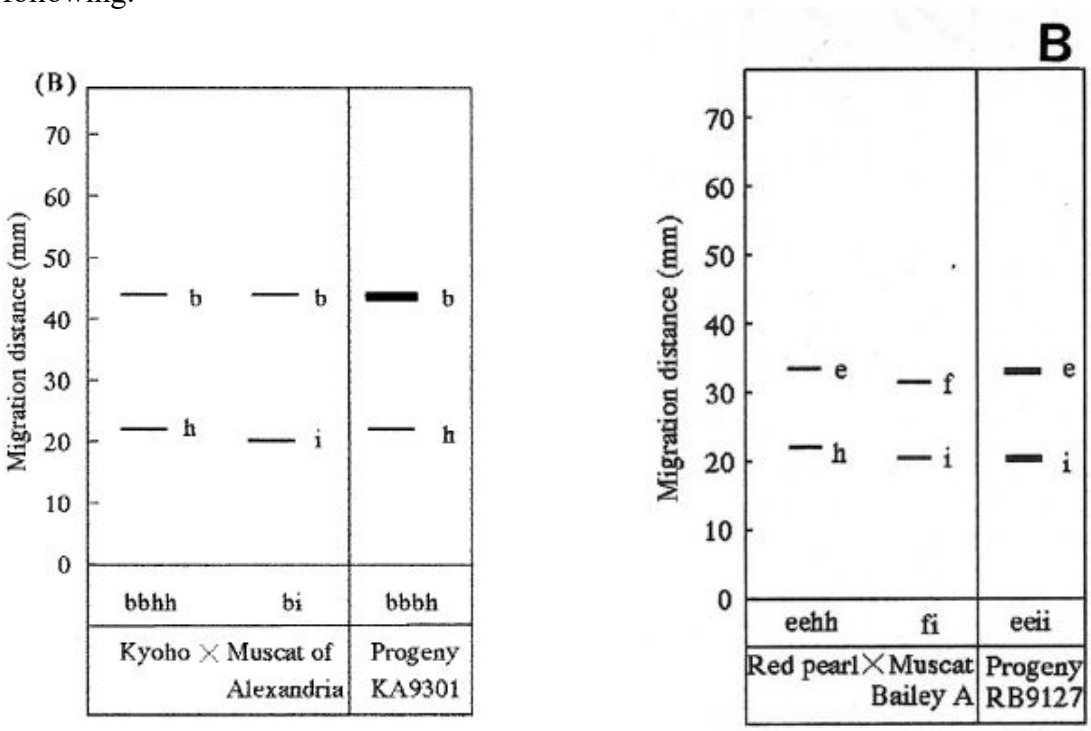
B. Name/describe the phenomenon shown in the photograph

C. What will be the end product after cell division is complete?

49. The following is from:

Park, S.M., A. Wakana, M. Hiramatsu, and K. Uresino. 2002. A tetraploid hybrid plant from 4x H 2x crosses in *Vitis* and its origin. Euphytica. 126: 345-353.

In this work, the authors made 8,057 4x-2x pollinations in grape, and got 4 tetraploid seedlings back. In an effort to determine if they were SDR or FDR, they studied isozymes and got the following:



The zymograms are for PGM2. The & on the left panel, being tetraploid, has four copies of the PGM2 gene, but only 2 alleles, so its genotype is *bbhh*. The % in that cross, being diploid, has two copies of the gene, and is heterozygous, its genotype being *bi*. The genotype of the 4x progeny is *bbbh*. The panel on the right is read in a similar fashion.

A. For each progeny, specify which two alleles came from the & and which two came from the %.

B. Based on these results, is it more likely that the pollen was FDR or SDR? Explain how you arrived at your answer.