1. Show how somatic segregation might occur as a result of somatic crossing over followed by normal chromosome behavior in somatic cells

2. The mechanism of somatic reduction in sorghum was elucidated by utilization of cytogenetic markers. Describe the genetic stocks used in this experiment. With your knowledge of natural and induced variation in the nucleolar organizer region, suggest one experiment which could provide evidence of the same mechanism, but using the NOR.

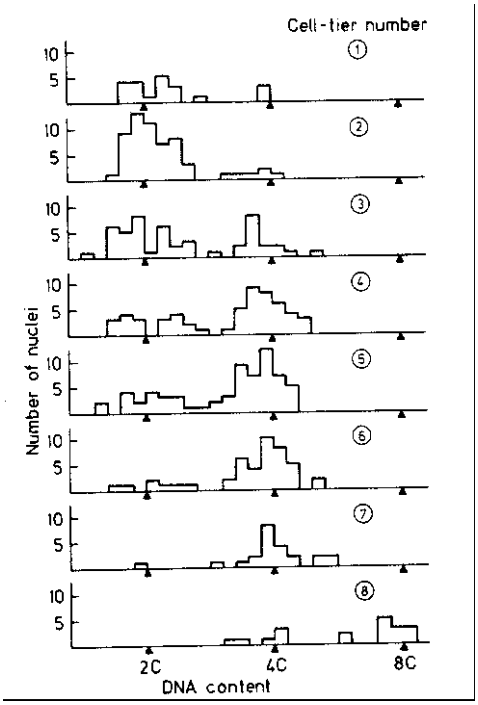
3. The table below is intended to compare and contrast polysomaty, polyteny, multinucleate cells, somatic reduction, and colchicine effects. Indicate with a "+" those characteristics typical of each phenomenon, and with a "o" those that do not occur:

Phenomenon	Chromosome duplication	Chromatid separation	Cytokinesis
Polysomaty			
Polyteny			
Multinucleate cells			
Somatic reduction			
Colchicine treatment			

4. The following is from Barlow, 1975:

The diagram depicts C values for cell nuclei in root tips of maize, cv Golden Bantam. Cell-tier 1 is the closest to the root-tip, and cell-tier 8 is the farthest away. Tiers 1 through 3 are still mitotically active.

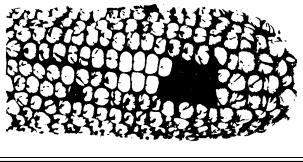
Name the phenomenon which is occurring here and explain how it happens. Limit your answer to this side of the page.



5. The corn cob at right was obtained from:

Brink, R.A., and R.A. Nilan. 1952. The relation between light variegated and medium variegated pericarp in maize. Genetics 37:519-544.

In corn, the *P* locus affects the coloration of the pericarp, thus altering the color of individual kernels. The P^V allele gives variegated kernels, and is dominant to P^R, which gives red kernels. In addition, the *Mp* allele (*P modulator*) is necessary for pericarp coloration, with *mpmp* pericarps being colorless. The *P* and *Mp* loci are loosely linked.



. Brink and Nilan, 1952. A region of colorless kernels next to a region of red kernels on a cob of variegated kernels.

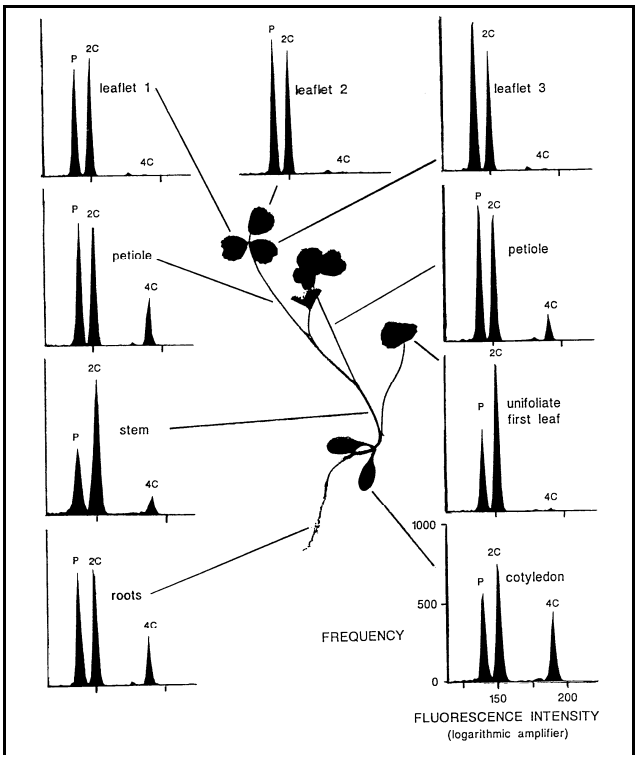
The authors were at a loss to explain the origin of this phenotype. However, this result has been explained by subsequent cytogeneticists (e.g., Schulz-Schaefer).

A) Name the phenomenon
B) Diagram the events leading to the phenotype in Figure 2.

6. The following diagram is from:

Blondon, F., D. Marie, S. Brown, and A. Kondorosi. 1994. Genome size and base composition in *Medicago sativa* and *M. truncatula* species. Genome 37: 264-270.

The authors used a flow cytometer to quantify DNA amounts in various tissues of alfalfa seedlings. In the diagram, the peaks represent fluorescence in arbitrary units. The tissues depicted are no longer undergoing mitosis. P = petunia DNA used as a standard. The presence of the 4C peak is an indication that a certain phenomenon has occurred. Name and describe this phenomenon and its end result, including a description of the cytological events that lead to its presence.



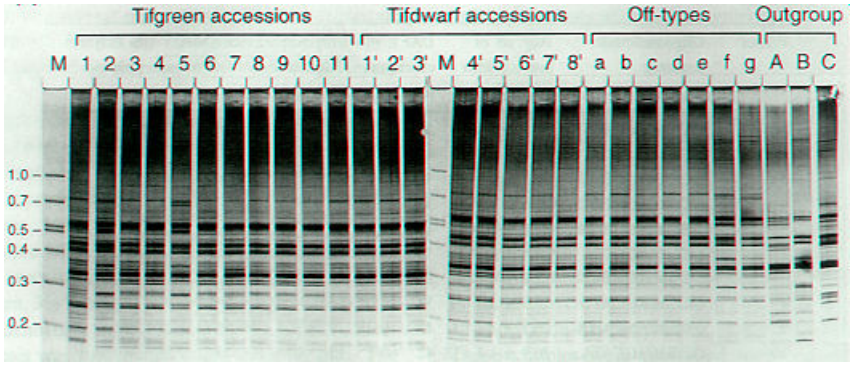
7. A cross between a dark green ($Y_{11}Y_{11}$) soybean and a yellow soybean ($y_{11}y_{11}$) results in a soybean with light green leaf coloration ($Y_{11}y_{11}$). Vig (1973: Genetics 73:583-596) observed pairs of spots (one dark green, the other yellow) on the leaves. Explain the results.

8. In the following article,

Caetano-Anollés, G. 1998. Euphytica 101:165-173

The author looked at Tiftgreen, a very popular bermudagrass cultivar released 1956. It is 2n = 3x = 27, and derived from Cynodon dactylon H C. transvaalensis. Being a triploid, this grass is sterile, and must be propagated vegetatively. Tiftdwarf is another cultivar, which arose in 1965 as a mutation from Tiftgreen. Despite the popularity of these grasses, lawns of Tiftgreen or Tiftdwarf get patches of contrasting morphology and performance, which leads to law suits. In one recent example, the owners of Joe Robbie Stadium in Miami sued due to the lack of uniformity of the turf in the stadium field.

The author wanted to investigate whether the off-type patches were due to contaminating genotypes, say from seed blown in by the wind, or due to something else. Therefore, the author used molecular markers to fingerprint the off-types. The authors concluded that the fingerprints (see figure) of the off-types were so similar to that of the original plant, that the off-types could not be due to contaminating genotypes. In the figure below, the term Aoutgroup@ means plants known to be of different genotype.

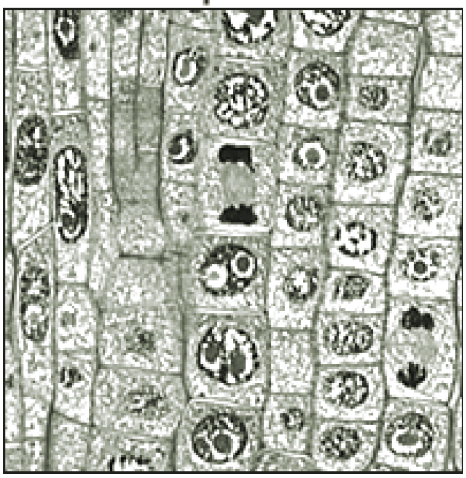


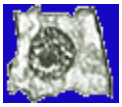
Name the phenomenon most likely resulting in the off-types, and describe 2 possible cytological bases for it. Use the backside of this page for your answer, but be brief about it.

9. Source: http://www.biology.arizona.edu/cell_bio/activities/cell_cycle/cell_cycle.html

At right is a photo of an onion root-tip. Individual cells have been isolated from the photo, and placed in the table below. Identify the stage of mitosis of each cell in the table, by writing I, P, M, A, or T next to each cell, to indicate the appropriate stage.

Cells in the tip of an onion root



	1	2	3	4
A				
B				
C				
D				
E				

10. The following diagram is of cells from flower petals of cabbage, as the petal grows. The diagram is from:

Nobuhiro, N. and Y. Kimura. 2002. J. Expt. Bot. 53:1017-1023.

The cells in row A are in the petal tip, while those in row B are at the base of the petal.

What is the most likely phenomenon that would account for the differences in cell size between the petal base and tip?

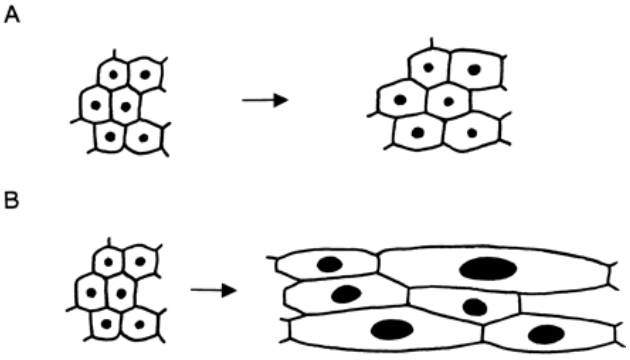


Diagram this series of events.

11. The following question comes from:

De Fátima, M., P.S. Machado, C.A. Aparecida Mangolin, and S. Aparecida de Oliveira Collet. 2000. Haseltonia 7:77-80.

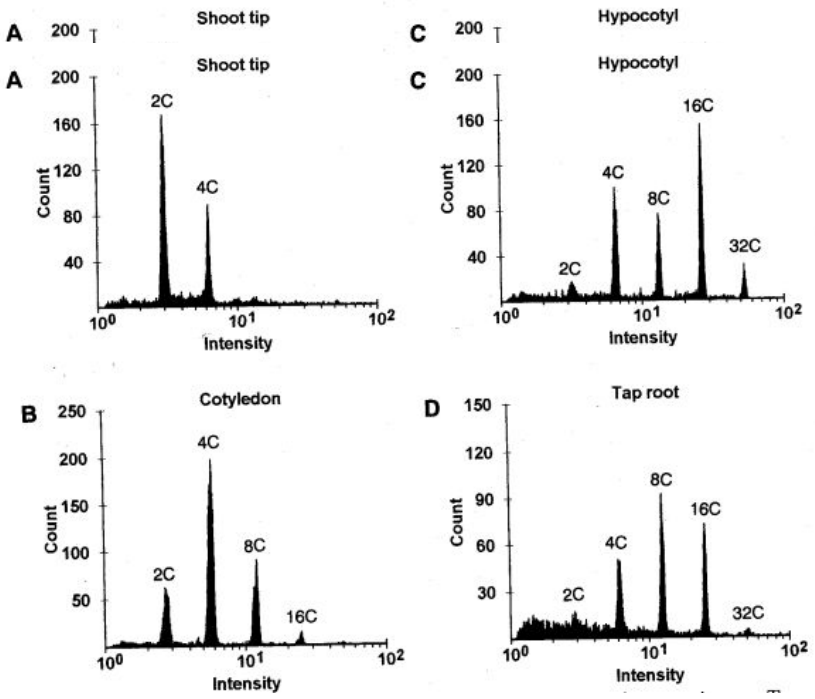
In the above study, the authors were studying plants regenerated from tissue culture of the cactus, *Cereus peruvianus.*

They first obtained callus from 3 seedlings which were heterozygous for an esterase isozyme, and were thus designated as having genotype *Est* -1 $^{1/2}$. However, an examination of the regenerated plants showed several individuals had become homozygous for the esterase -1 allele, and thus were designated as *Est* -1 $^{1/1}$. The original seedlings were also heterozygous for other esterase loci, but these loci were not affected by the regeneration process.

What is the most likely explanation for this phenomenon, and why is this the most likely explanation?

12. The following is from:

Kudo, K., and Y. Kimura. 2002. Plant Biotechnology 19:45-52.



In this study, the authors were looking at the DNA content in nuclei taken from different parts of radish seedlings.

A) Name this phenomenon and

B) Explain why all the nuclei are not 2C.

13. The following is from: Wang, R.R.-C., X. Li, and N.J. Chatterton. 2001. A proposed mechanism for loss of heterozygosity in rice hybrids. Euphytica 118: 119-126.

In this work, the Chinese rice cultivar, >Zhongxin No. 1' was crossed with the US cultivar, >M202 #2'. The parents were heterozygous at 14 different RAPD markers. However, it was possible to obtain F2 plants which were completely homozygous for every one of the 14 RAPD markers.

What is the most likely explanation for this phenomenon, and why is this the most likely explanation? Diagram this phenomenon:

14. The following data come from the following paper: Choy, M.-K. and S.-B. Teoh. 2001. Caryologia 54:261-266.

Abstract (edited for clarity): Eumusa series of banana contains the majority of commercially important cultivars, most of which are interspecific hybrids of two wild species of bananas, *Musa acuminata* Colla (AA Group) and *Musa balbisiana* Colla (BB Group). Most of the banana cultivars are diploids or triploids. Occurrences of 'laggard' and 'bridge' during mitotic anaphase were considered as aberrant. Aberrant anaphase cells were observed in the root tip cells of wild *Musa acuminata* Colla (AA Group) and *M. balbisiana* Colla (BB Group) and of the common Malaysian banana cultivars: Pisang Mas (AA Group), Pisang Berangan (AAA Group), Pisang Rastali (AAB Group), Pisang Raja (AAB Group), Pisang Awak (ABB Group) and Pisang Abu Nipah (BBB Group). Frequencies of aberrant anaphase cells were scored and statistically analyzed.

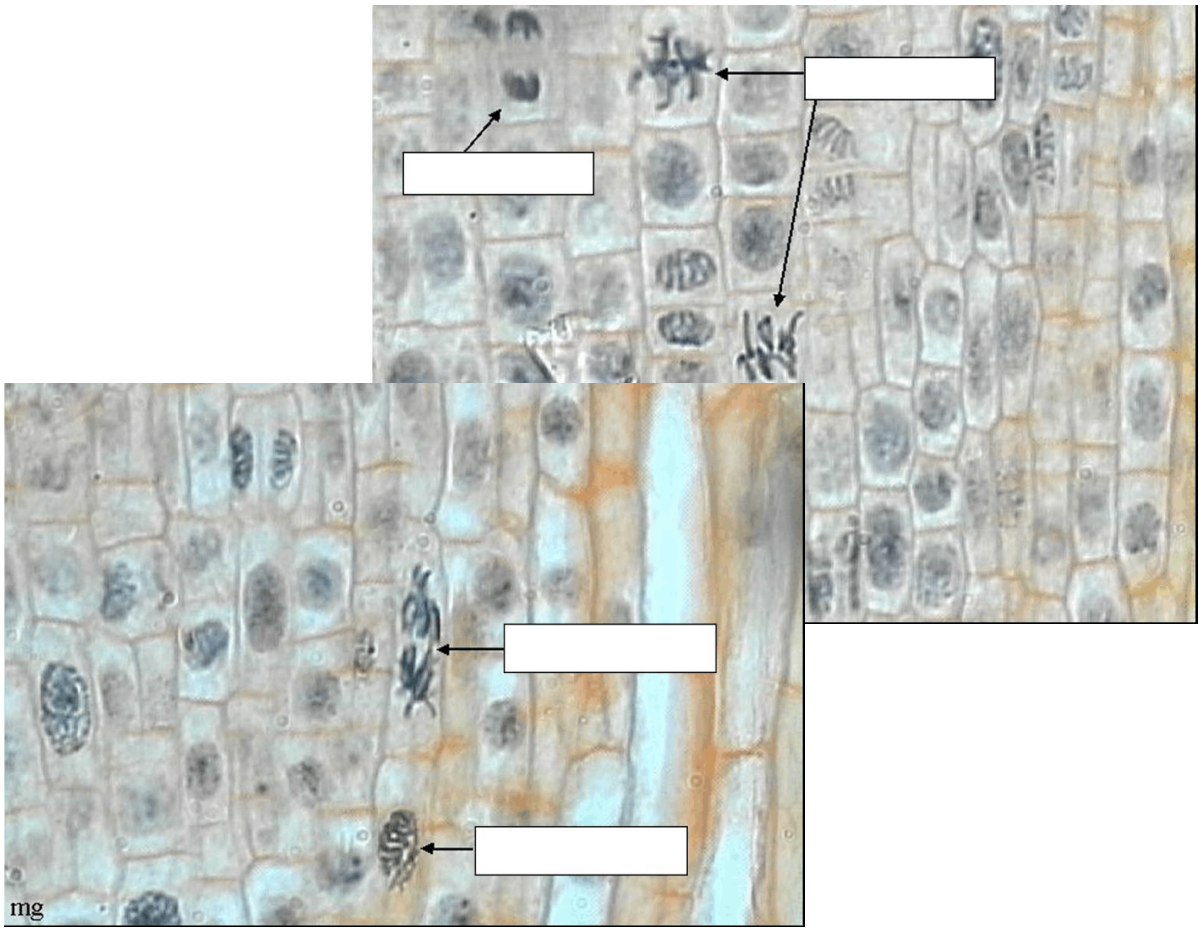
Data are as follows: (Note: the term AAB means it is a triploid, with 2 sets of chromosomes from *Musa acuminata*, and one from *M. balbisiana*, and so forth.)

Species or cultivar	Genomic constitution	Freq. of aberrant anaphase cells
wild *M. acuminata*	AA	0.12875
wild *M. balbisiana*	BB	0.09125
Pisang Mas	AA	0.09125
Pisang Rastali	AAB	0.07000
Pisang Awak	ABB	0.05625
Pisang Berangan	AAA	0.05375
Pisang Raja	AAB	0.05375
Pisang Abu Nipah	BBB	0.02625

The phenomenon being studied here is an example of what?

15. **Source:** http://faculty.clintoncc.suny.edu/faculty/Michael.Gregory/default.htm

Label the 4 squares in the photo with the stage to which the arrow is pointing.



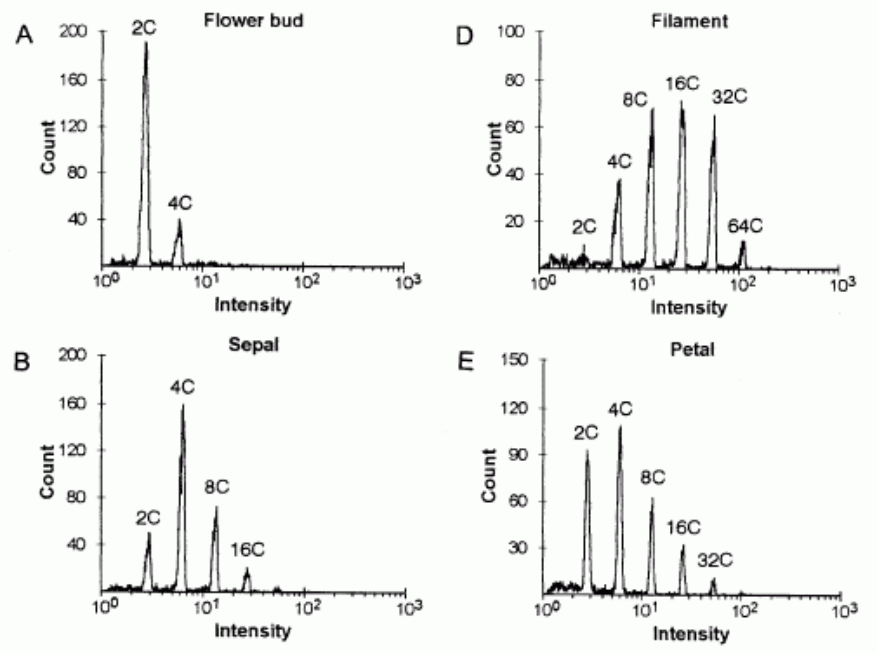
16. **The following is from:**

Kudo N and Y Kimura. 2001. [...] in cabbage *(Brassica oleracea* L.) flowers. Sex. Plant Reprod. 13:279-283.

A) What phenomenon is taking place in the various plant tissues as the flower buds mature, and what is the name of the process that leads to that phenomenon?

B) What is C?

C) Name the instrument used to make these measurements and explain the main principles behind how it works.



Do not exceed the amount of space available on this page and its back side.

17. The following is from: http://www.youtube.com/watch?v=_REVJ6uyCow

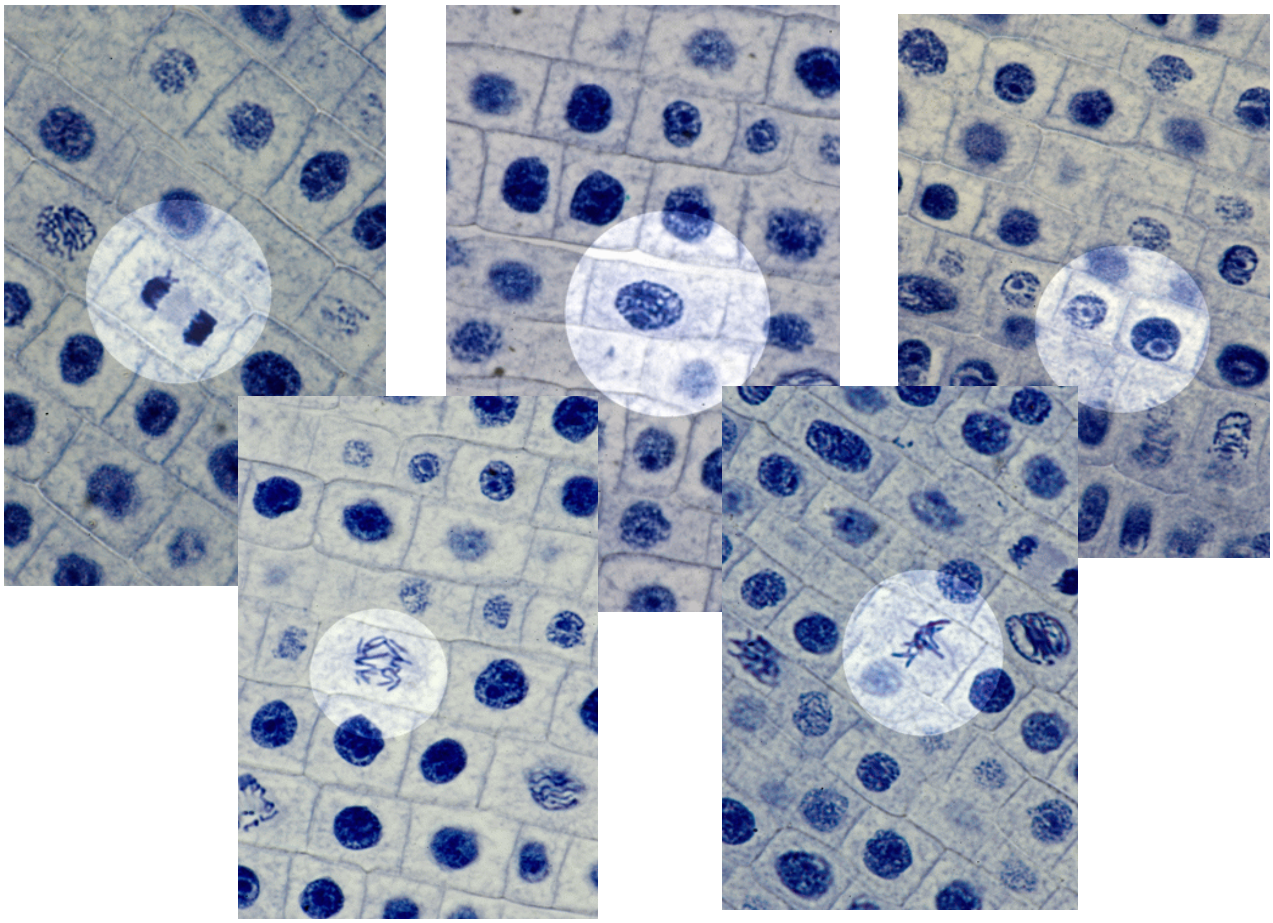
You will see a YouTube video on mitosis.
A) Creative as it may be, it is rife with mistakes.
Point out 4 major mistakes

B) All or nothing, for 5 extra credit points. Give name and artist of the background music.

18. **The following is from**

Onion Root Mitosis, by Joseph C. Rossi. 2004. http://www.microscopy-uk.org.uk/mag/artnov04macro/jronionroot.html
(submitted as part of a student project).

Label the stage of the highlighted cells in the photos below.



19. **The following is from:**

Carlson, 1974. Genet Res Camb 24:109-112.

In this paper, a dark green sector appeared adjacent to a light green one on a leaf of a tobacco plant heterozygous at the *Su* and *cl* loci and which had been exposed to gamma rays.

- The *cl* locus gives a chlorotic (ie, light green) phenotype when homozygous recessive.
- The Su locus (for Sulfur) controls the number of chloroplasts in a cell, and hence determines how green the leaf is.

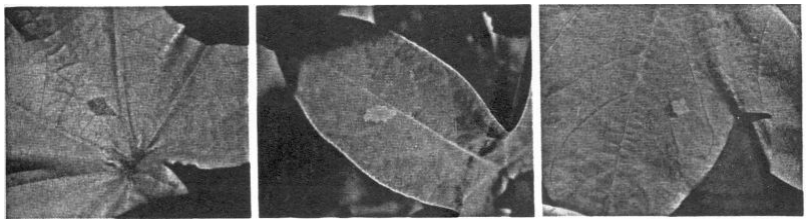
A) name the phenomenon observed

B) Diagram the events that result in this phenotype

21.

20. The following is from:

Barrow et al., 1973. Journal of Heredity, 64:222-226.



Left: green spot; Middle: yellow spot; Right: green & yellow spots next to each other.

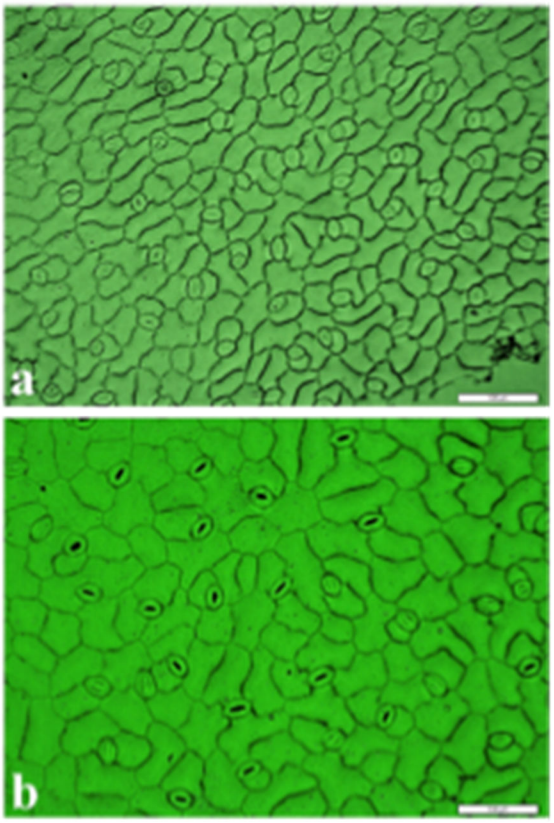
In cotton, leaves of plants heterozygous at the V locus are virescent in color. The homozygous dominant is green, and the homozygous recessive is yellow.

A) Diagram how the twin spots in the photo might be obtained:

B) Can the single spots be explained in terms of somatic crossover? _____

C) If your answer is no, propose another legitimate mechanism that can create single spots (5 points extra credit)

21. **The following is from:**
Beyaz et al. 2013. Sugar beet (*Beta vulgaris* L.) growth [ ]. Caryologia. 66:90 -95



Top photo = cv Felicita

Bottom photo = cv AD 440

A) Why would AD440 have larger epidermal cells than Felicita?

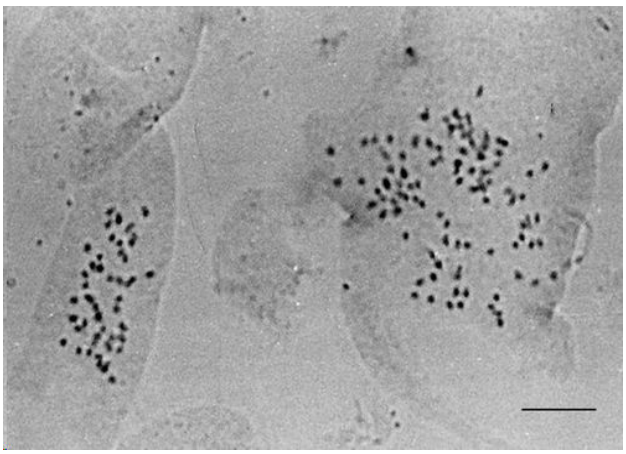
B) How would you verify the cause? List two ways.

C) If your premise from A) is correct after B) has been done, you would conclude you are looking at a phenomenon called _____ that results from a process called _____.

D) Diagram this latter process:

22. The following is from:

Dahmer. 2012. Occurrence and significance of [...] in species of *Mimosa* L. Caryologia. 208-215.

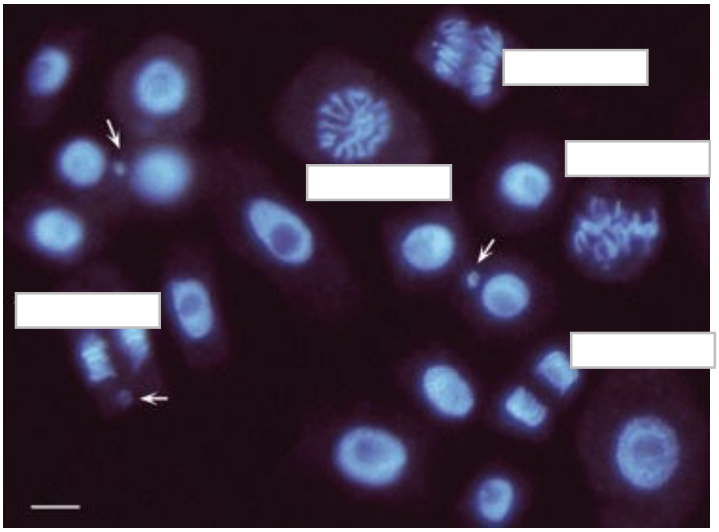


The photo at left shows 2 adjacent root tip cells of *M. incana*, 2n =4x = 52.

A) Name the phenomenon shown by the cell on the right.

B) What is the expected volume of the cell on the right compared to that on the left?

23. **The following is from:**
https://www.researchgate.net/publication/50890741_Organisation_of_the_plant_genome_in_chromosomes



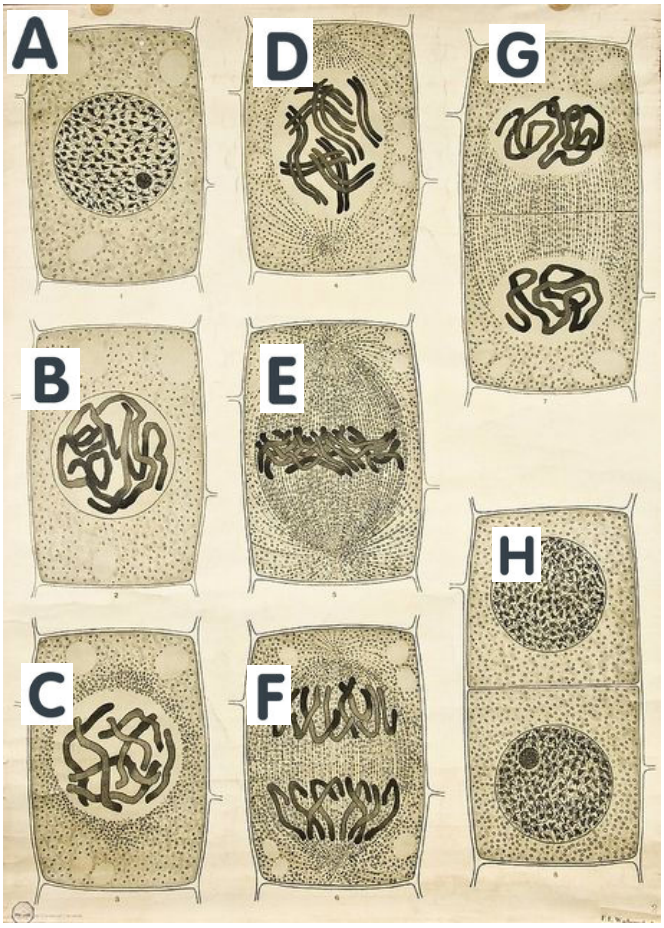
The photo shows root tips of a barley x rye cross.

A) What stain is being used?

B) Identify the stage of division for the indicated cells.
C) What are the arrows pointing to, and what does it imply about the stability of the hybrid?

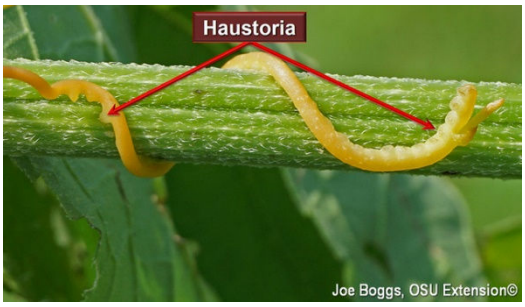
24. The following is from:
Elving, Frederik. 1929. Anatomia Vegetal, FE Wachsmuth (Leipzig).

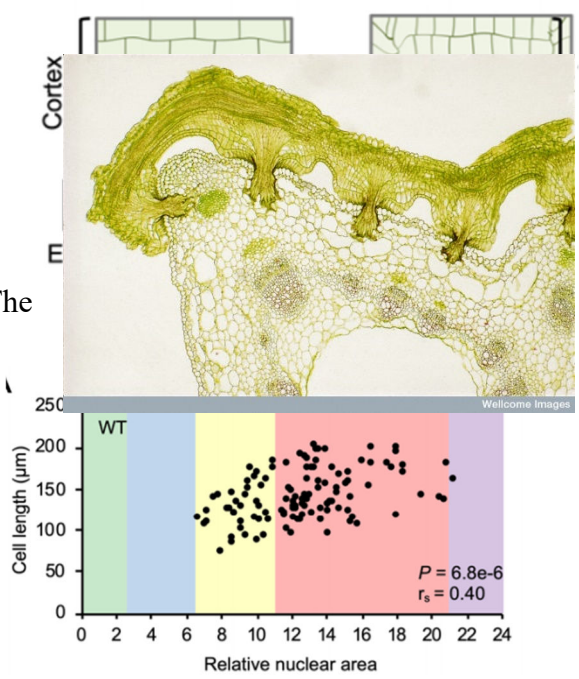
For each stage depicted in the diagram, give the name of the stage



25. **The following is from: (will be given after the exam)**
Nishitani K. 2020. Host-produced ethylene is required for marked cell expansion and endoreduplication in dodder search hyphae. Plant Physiology on line first. https://doi.org/10.1093/plphys/kiaa010

Dodder (*Cuscuta* spp.) is a genus of parasitic plants that look like yellow strings that coil around another plant. They have cell patches (haustoria) that grow into the host plant and draw nutrients from it. They are shown in the photos at right and the diagram below.





The authors looked at cells in the haustorium, and produced the following result:

A. What is the phenomenon that is going on inside these cells?

B. Describe the series of steps that are involved in getting to 32C.

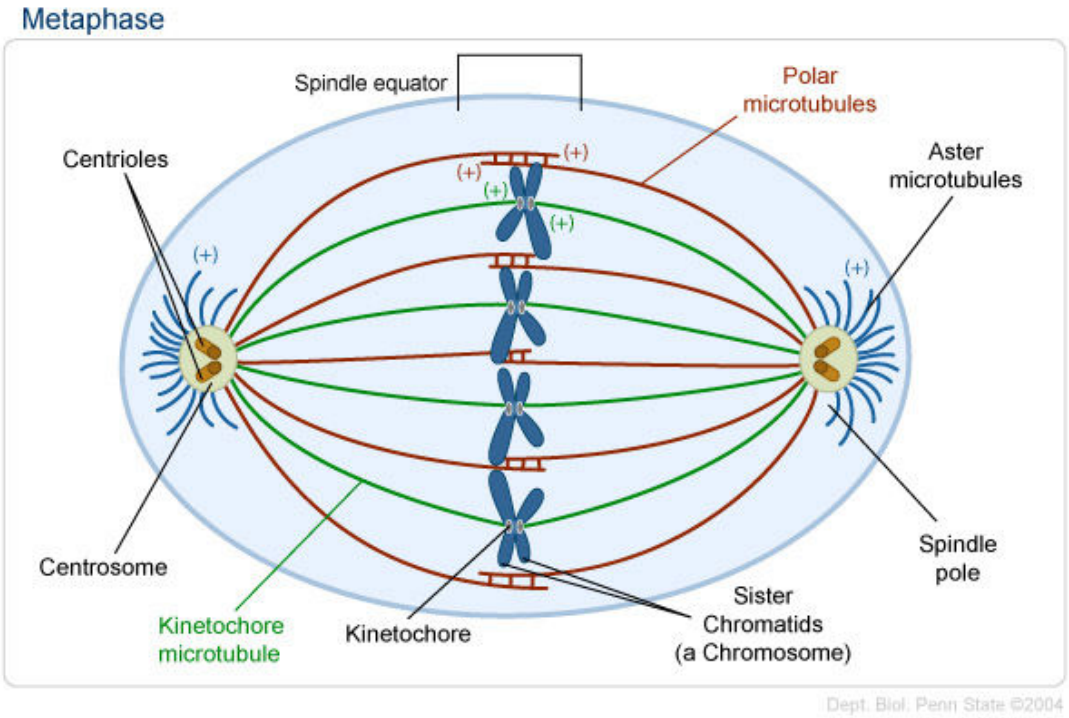
.

26. **Extra credit**

The following is from: https://www.pinterest.com/qmjacobs/michigan-high-school-biology-standard-b4-genetics-/

A. By now, you have seen lots of photos of plant cells undergoing division. Is the following diagram of a plant cell? Yes No

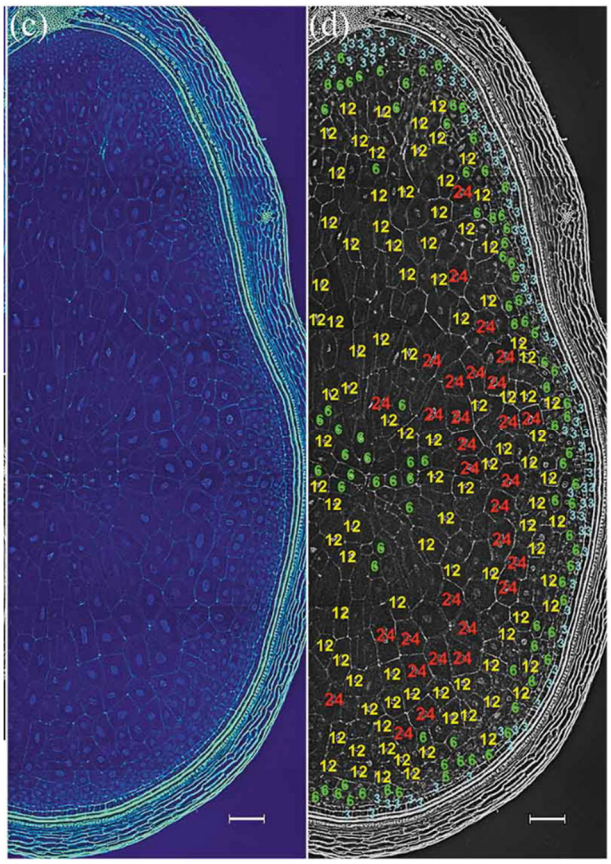
B. Specify the features(s) that lead to your answer.



27. The following is from the reference below, which will be posted after the exam:

Kobayashi H. 2019. Variations of endoreduplication and its potential contribution to endosperm development in rice (*Oryza sativa* L.). Plant Production Science, 22(2): 227-241.

The figures show DAPI staining of cross section of the rice endosperm, and then the ploidy associated with the individual cells shown.



a) Name the phenomenon shown and the process that leads to it.

b) What role would this phenomenon play in the developing endosperm?

c) The author noted the correlation between cell size and ploidy. Is this just a correlation or is it cause-and-effect? Explain your answer.

d) Endosperm cell walls contribute to the texture of cooked rice. So, why would cell size affect (or not affect) texture?

e) The author looked at 10 genotypes, and found that they differed in terms of i) average ploidy of all nuclei, ii) proportion of nuclei ≥ 6C, and iii) average ploidy of nuclei ≥ 6C. What inferences can you draw from this observation in terms of what controls the phenomenon and whether is amenable to breeding and selection.

28. The following is from the reference below, which will be posted after the exam:

Ali MF, JM Shin, U Fatema, D Kurihara, F Berger, L Yuan & T Kawashima. 2023. Cellular dynamics of coenocytic endosperm development in *Arabidopsis thaliana*. doi.org/10.1038/s41477-022-01331-7

The diagrams below show nuclei in the developing arabidopsis endosperm.

a) Name the process depicted in photos a-e? What is the resulting tissue called?