PLNT3140 INTRODUCTORY CYTOGENETICS

MID-TERM EXAMINATION

1 p.m. to 2:15 p.m.   Tuesday, October 15, 2019

Answer any combination of questions totalling to exactly 100 points. If you answer questions totalling more than 100 points, answers will be discarded at random until the total points equal 100. There are 13 questions to choose from, totaling 120 points. This exam is worth 20% of the final grade.

Hand in these question sheets along with your exam book.

Ways to write a readable and concise answer:
i. Just answer the question. Save time by specifically addressing what is asked. Don't give irrelevant background if it doesn't contribute to the question that was asked.
ii. Avoid stream of consciousness. Plan your answer by organizing your key points, and then write a concise, coherent answer. Make your point once, clearly, rather than repeating the same thing several times with no new information.
iii. Point form, diagrams, tables, bar graphs, figures are welcome. Often they get the point across more clearly than a long paragraph.
iv. Your writing must be legible. If I can't read it, I can't give you any credit.

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1. (10 points) In multicellular organisms, some cells such as epidermal cells in skin, divide on a regular basis, particularly in response to tissue damage. Other cell types such as neural cells have highly specialized structure and function, and undergo very little cell division. Instead, they carry out their functions, some times for many years. In which types of cells would would you expect to see G1, and in which would you expect to see G0. Explain your reasoning.

2. (10 points) Most crops are propagated through sexual crosses. Bananas are an example of a crop that is propagated asexually by planting cuttings from mature plants. This is necessary because commercial banana varieties employ female sterility to give seedless fruit. How would genetic diversity in populations of vegetatively propagated crops differ from crops that reproduce sexually? What are the two mechanisms in sexual reproduction are absent in vegetative propagation, contributing to these differences in genetic diversity?

3. (10 points) Carnoy's solution (glacial acetic acid:ethanol, 1:3), originally used only as a fixative for various cell types, has been discovered to help treat certain types of tumors. After a tumor is surgically removed, Carnoy's solution is generally applied to the area in case some tumorous cells remain. Explain why Carnoy's solution would be effective in stopping growth of cells. Thinking back to the discussion of pre-treatment and fixation of different types of tissues, what might be some of the potential limitations of this method?

4. (10 points) The table below gives Mitotic cycle time (h) in several plant species. What can you conclude regarding the relationship between mitotic cycle time and the number of chromosomes, or the ploidy level.

Species	**2n**	**Ploidy level**	**Mitotic cycle (hr.)**	**Reference**
Haplopappus gracilis	4	2x	10.50	Sparvoli et al., 1966
Crepis capiliaris	6	2x	10.75	Van't Hof, 1965
Trillium erectum	10	2x	29.00	Van't Hof and Sparrow, 1963
Tradescantia paludosa	12	2x	20.00	Wimber, 1960
Vicia faba	12	2x	13.00	Van't Hof and Sparrow, 1963
Impatiens balsamina	14	2x	8.80	Van't Hof, 1965
Lathyrus angulatus	14	2x	12.25	Evans and Rees, 1971
Lathyrus articularis	14	2x	14.25	Evans and Rees, 1971
Lathyrus hirsutus	14	2x	18.00	Evans and Rees, 1971
Avena strigosa	14	2x	9.80	Yang and Dodson, 1970
Secale cereale	14	2x	12.75	Ayonoadu and Rees, 1968
Alliam cepa	16	2x	17.40	Van't Hof, 1965
Allium fistulosum	16	2x	18.80	Van't Hof, 1965
Hyacinthus orientalis	16	2x	24.00	Evans and Rees, 1971
Zea mays	20	2x	10.50	Evans and Rees, 1971
Melandrium album	22	2x	15.50	Choudhun, 1969
Lycopersicon esculentum	24	2x	10.60	Van't Hof, 1965
Tulipa kaufmanniana	24	2x	23.00	Van't Hof and Sparrow, 1963
Avena strigosa	28	4x	9.90	Yang and Dodson, 1970
Pisum sativum	28	4x	12.00	Van't Hof et al., 1960
Triticum durum	28	4x	14.00	Avanzi and Deri, 1969
Allium tuberosum	32	4x	20.60	Van't Hof, 1965
Helianthus annuus	34	2x	9.00	Van't Hof and Sparrow, 1963
Triticum aestivum	42	6x	10.50	Bennett, 1971
Table 3.1 From Singh, R.J. (1993) Plant Cytogenetics CRC Press				

5. (10 points) What is the relationship between nuclear DNA content and chromosome number? What is the relationship between nuclear DNA content and meiotic cycle time?

Table 3.3 Duration of meiosis (h) in diploid species

Species	2n	Meiotic cycle (hr.)	DNA per cell (picograms)
Antirrhinum majus	16	24.0	5.5
Haploppapus gracilis	4	36.0	5.5
Secale cereale	14	51.2	28.7
Allium cepa	16	96.0	54.0
Tradescantia paludosa	12	126.0	59.0
Tulbaghia violacea	12	130.0	58.5
Lilium henryi	24	170.0	100.0
Lilium longiflorum	24	192.0	106.0
Trillium erectum	10	274.0	120.0

Note: Results from several authors; data taken at different temperatures, however, provide convincing evidence. From Bennett, M.D. 1971. *Proc. Royal Soc. London Ser. B*., 178:277-299.

6. (10 points) Given the data listed below, calculate

a) the physical length of the DNA in a diploid *Vicia faba* cell
b) The ratio between the length of the DNA, and the total length of the chromosomes

- Combined length of all *Vicia faba* metaphase (root tip) chromosomes: 0.112 mm
- *Vicia faba* diploid genome size: 14.6 pg= 1.33×10^{10} bp
- 1 helical turn of a DNA duplex = 10 bp = 3.4 nm

7. (5 points) The following diagram shows the DNA sequence of a human telomere. Write out sequence of the RNA carried by the human telomere terminal transferase. Make sure to label the 5' and 3' ends of the RNA.

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            5'CCCTAACCCTAA--------------------------
3'GGGATTGGGATTGGGATTGGGATT--------------------------------
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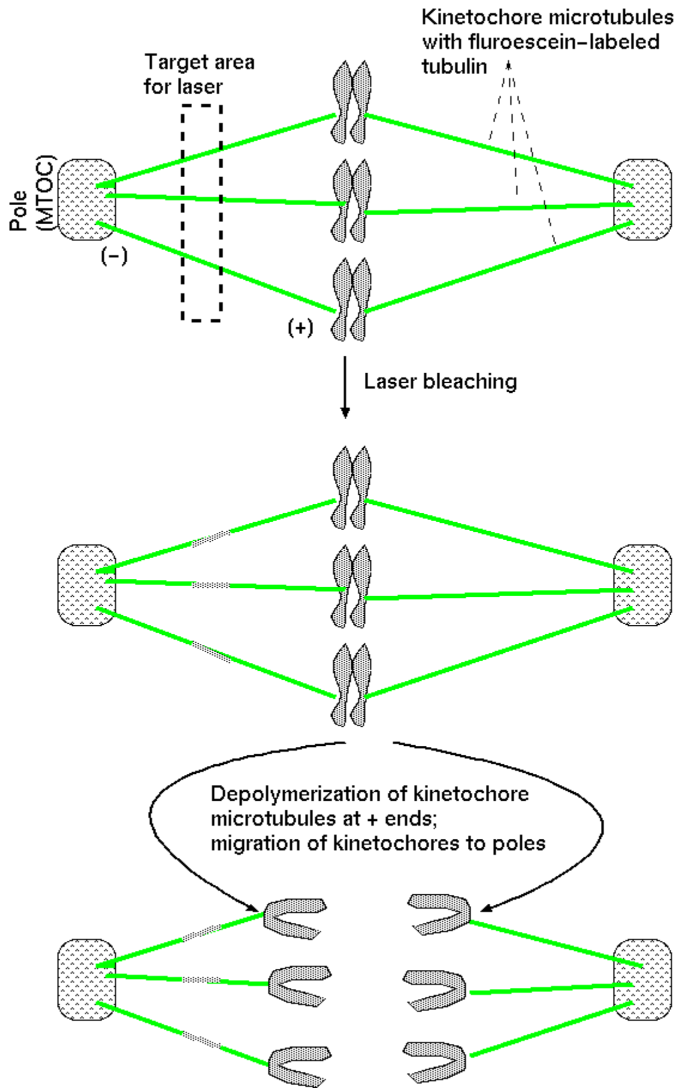
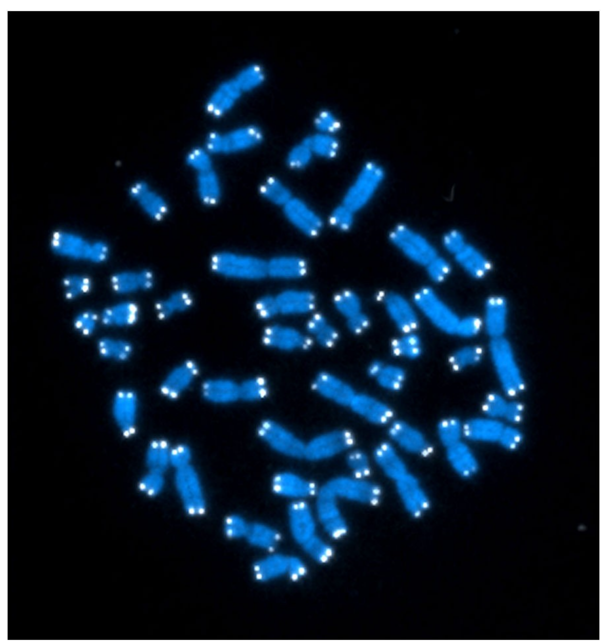
8. (10 points) The diagram at right illustrates an experiment whose purpose was to distinguish between 2 alternative hypotheses regarding chromosome migration during anaphase of mitosis. State the two hypotheses. Which one was correct, and what was the observation that led to that conclusion?

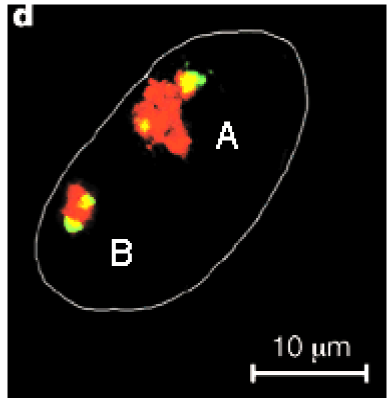


9. (5 points) The image shows a mitotic chromosome spread in which chromosomes were FISH was performed. What was the identity of the FISH probe that was used?



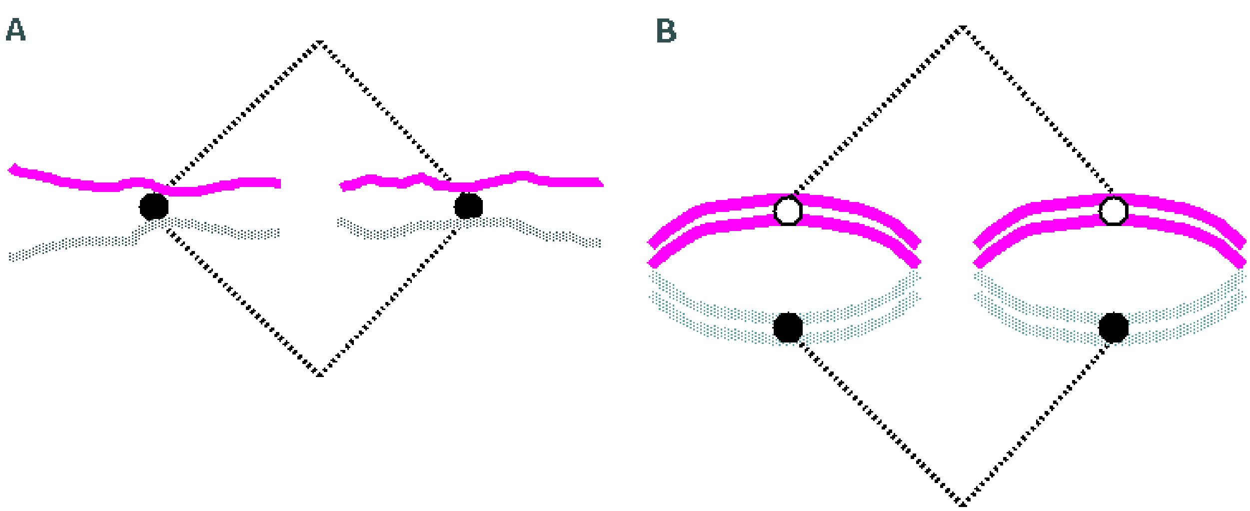
10. (15 points) Suppose you wanted to genetically engineer plants to express a disease resistance gene constitutively, using the 35S promoter. In doing so, you want to eliminate the problem that when genes insert at random chromosomal sites, some sites are favorable to expression of the foreign gene, and others tend to express the gene weakly, or not at all. What is a common mechanism for these site-specific differences in expression? Draw a simple map of a recombinant construct designed to overcome this problem. Explain how the construct solves the problem.

11. (5 points) The accompanying figure shows two human X chromosomes in the interphase nucleus of a human female, visualized using chromosome painting. In humans, genes on one X chromosome are actively transcribed, while genes on the other are not transcribed. The inactive chromosome is often referred to as a Barr Body. Which chromosome in the picture is active and which is inactive? State your reasons.



12. (5 points) The rye genome has 7 chromosome pairs. Ignoring crossing over, how many distinct gametes can be produced by Mendelian segregation during meiosis?

13. (10 points) One of the diagrams below illustrates meiotic metaphase I, and the other illustrates mitotic metaphase I. Based on what you know about mitosis and meiosis, which one is A, and which one is B? Explain your choice.



14. (5 points) A space-filling model of nucleosome structure is shown below. Each little sphere represents a single atom. This model brings out how perfectly the DNA helix and nucleosome core particle fit together. Histones are probably the most highly conserved proteins known. For example, H4 is 102 aa. long in both pea and cow, with two aa substitutions. H3 is identical between pea and cow at 131 out of 135 positions. Considering nucleosome structure, why does it make sense that very little mutation has been seen in histones, even amoung widely diverged taxa like plants and anumals?