PLNT3140 INTRODUCTORY CYTOGENETICS

MID-TERM EXAMINATION

1 p.m. to 2:15 p.m. Tuesday, October 16, 2018

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. (5 points) Most people's eyes are not optically balanced. For example, one eye might be a bit nearsighted, and the other far sighted. Most microscopes have two eyepieces for stereo vision, but only one of those eye pieces can be focused, while the other eyepiece is at a fixed focal length, with respect to the objective lens. What can you do to adjust the microscope so that both eyes are correctly focused?

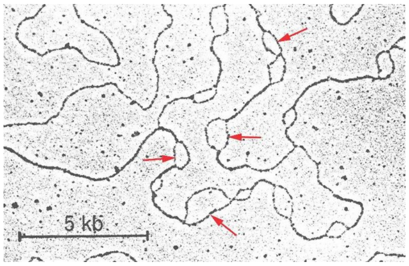
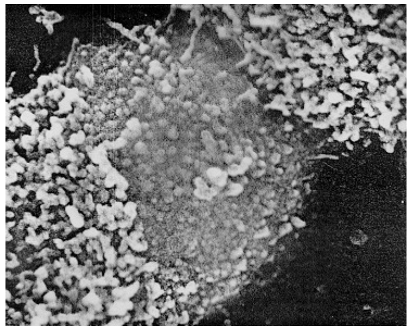
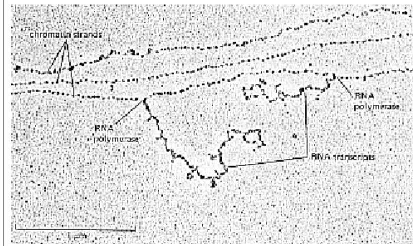
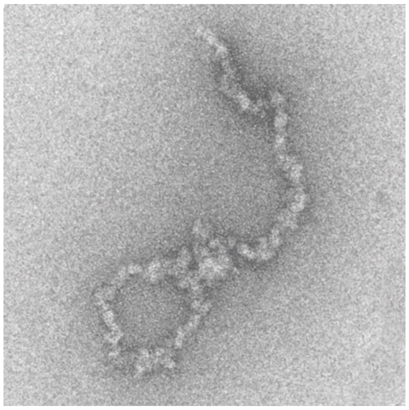
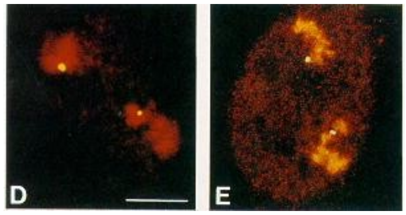
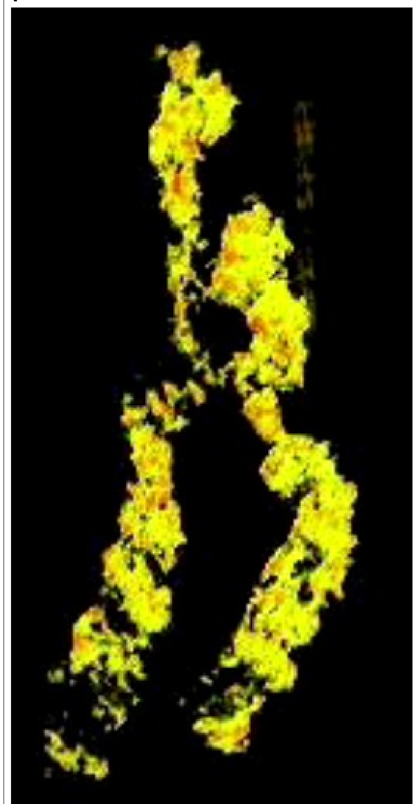
2. (10 points) In the photo at right, onion chromosomes are shown during mitosis.

a) Which stage of mitosis is this? Explain.

b) Why do the chromosome arms point in opposing directions?

3. (10 points) List the five main Histone proteins. Tell which ones are in the nucleosome core particle, and which serve as linkers between nucleosomes.

4. (10 points) Below are five statements and six figures. Match each statement with the figure that best describes it. One of the figures is not relevant to any statement, and has no match.

A	B	C
		
D	**E**	**F**
		

I. Telomeres are protected from degradation by exonucleases through the formation of a D-loop, in which the terminal repeats base pair with internal copies of the repeats.

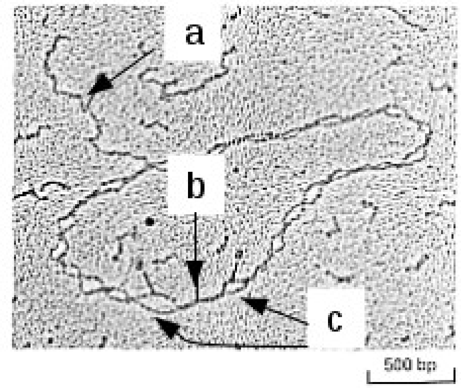
II. Eukaryotic chromosomes have multiple origins of replication.

III. The chromatin structure of in the vicinity of centromeres is different from chromatin structure in the rest of the chromosome.

IV. The highest order level of coiling for metaphase chromosomes is a helical structure.

V. DNA is packaged in nucleosomes even in actively-transcribed genes.

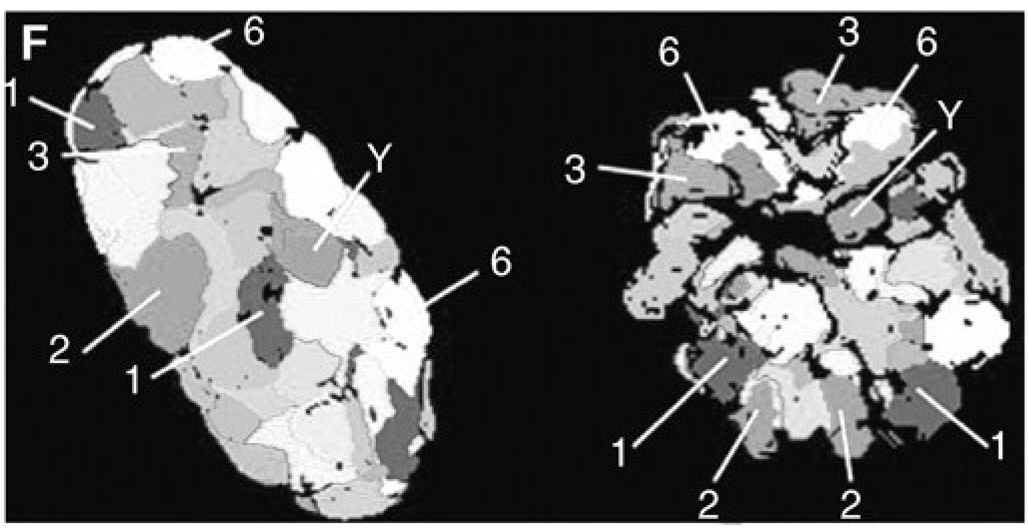
5. (5 points) In the figure at right, circular SV40 DNA is shown from a psoralen-UV crosslinking experiment in which nucleosomal DNA was protected from crosslinking, while the spacer DNA between nucleosomes was not protected.



Which letters refer to

- an RNA transcript
- single-stranded DNA
- double-stranded DNA

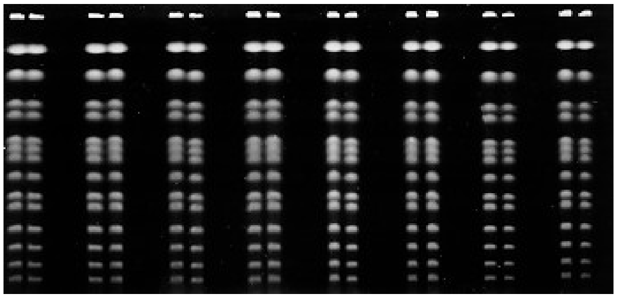
6. (10 points) A 3D reconstruction of a human nucleus is shown in the left panel of Figure F. The identities of chromosome territories, as visualized by FISH, are marked with numbers. A similar image from another cell is shown in the right panel. Which stage of mitotis is represented in the right panel? Explain your choice.



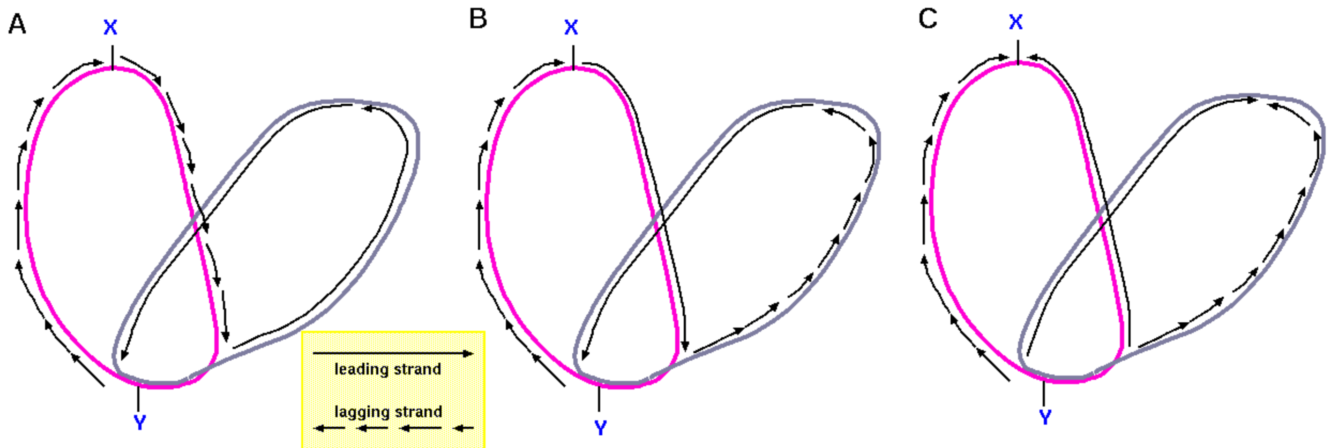
7. (10 points) In multicellular organisms, some cells such as epidermal cells in skin, divide on a regular basis, particularly in response to tissue damage. Other cell types such as neural cells have highly specialized structure and function, and undergo very little cell division. Instead, they carry 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.

8. (5 points) The figure below shows Pulsed Field Gel Electrophoresis (PFGE) of yeast (*Saccharomyces ceriviscea*) chromosomal DNA. Each band corresponds to a chromosome, and the sizes of the chromosomes are all known.

Suppose you had a cloned sequence for a gene from the ascomycete fungus, *Neurospora crassa*. What would be a simple way to find out which chromosome has the corresponding yeast gene?



9. (10 points)



a) DNA replication in a circular chromosome is illustrated above. Which of the three is correct. Explain what is wrong with the other two.

b) What do the labels X and Y indicate?

c) How many replication forks are shown in the diagram?

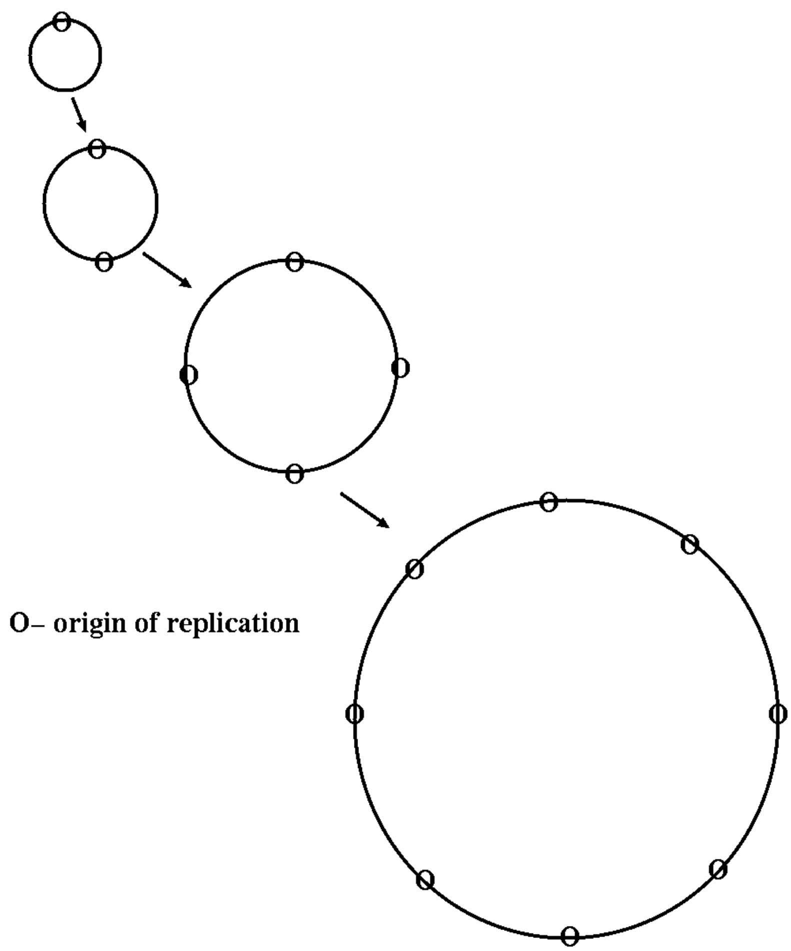
d) How many replicons are shown in the diagram?

10. (15 points)

a) The figure below is a speculative model that illustrates one possible step in the evolution of the eukaryotic chromosome from a prokaryotic chromosome. As chromosomes got bigger, it took longer to replicate them. Consequently, selection favored chromosomes with multiple replication origins. What advantage would there be to having larger chromosomes? (Hint: think about the differences between prokaryotes and eukaryotes.)

b) One disadvantage of having a larger chromosome is that if a break occurs, it is harder for the two ends to find each other, such that the chromosome can recircularize. What would happen if the chromosome can't recircularize, after a break?

c) Suppose that, in a distant ancestor of the modern eukaryote, an enzyme evolved that could add short DNA sequences to the ends of broken chromosomes. What benefit would this give to the cell? To what modern enzyme would this ancestral enzyme correspond?



11. (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				

12. (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.

13. (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?