PLNT3140 INTRODUCTORY CYTOGENETICS

MID-TERM EXAMINATION

1 p.m. to 2:15 p.m. Thursday, October 19, 2017

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. This exam is worth 20% of the course grade. 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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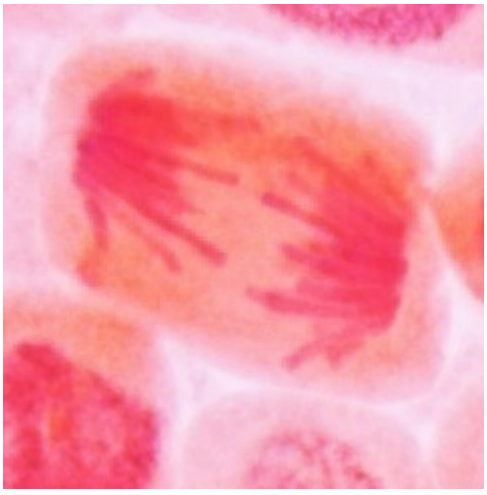
1. (5 points) Most people's eyes are not perfectly balanced. For example, one eye might be a bit nearsighted, and the other far sighted. Most microscopes have two eyepieces for stereo vision, but only one of those eye pieces can be focused, while the other eyepiece is at a fixed focal length, with respect 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.

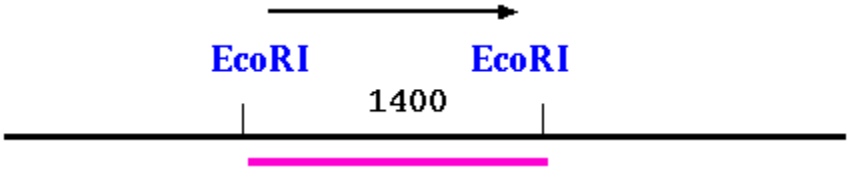
a) Which stage of mitosis is this?

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



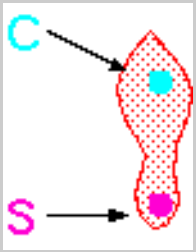
3. (10 points) List the five main Histone proteins. Tell which ones are in the nucleosome core particle, and which serve as linkers between nucleosomes.

4. (10 points) A restriction map is shown, in which a gene is known to be flanked between two Eco RI sites. The 1400 bp Eco RI fragment was used to transform plants. In one transformed plant, a copy of this gene was incorporated at random into loci on 5 different chromosomes. Genomic DNA from that transformant plant was examined by Southern Blotting, using the same 1400 bp band as a hybridization probe. In one lane, genomic DNA was digested with Eco RI (5'G^AATTC3'), and in the other lane, DNA was digested with HindIII (5'A^AGCTT3'). It is known that there are no HindIII sites present in this 1400 bp fragment. Draw what you would expect the Southern to look like, for each digest.



5. (10 points) Consider a cross between two parents CCSS x ccss. Of 96 progeny in the F2 generation, the counts for each of the four phenotypic classes are listed in the table. Probes for each of these loci were used in Fluorescent In-situ Hybridization, showing that the C and S probes hybridize to sites on two different arms of the same chromosome, as indicated at right.

Phenotypic class	Number of progeny
CS	54
Cs	18
cS	18
cs	6

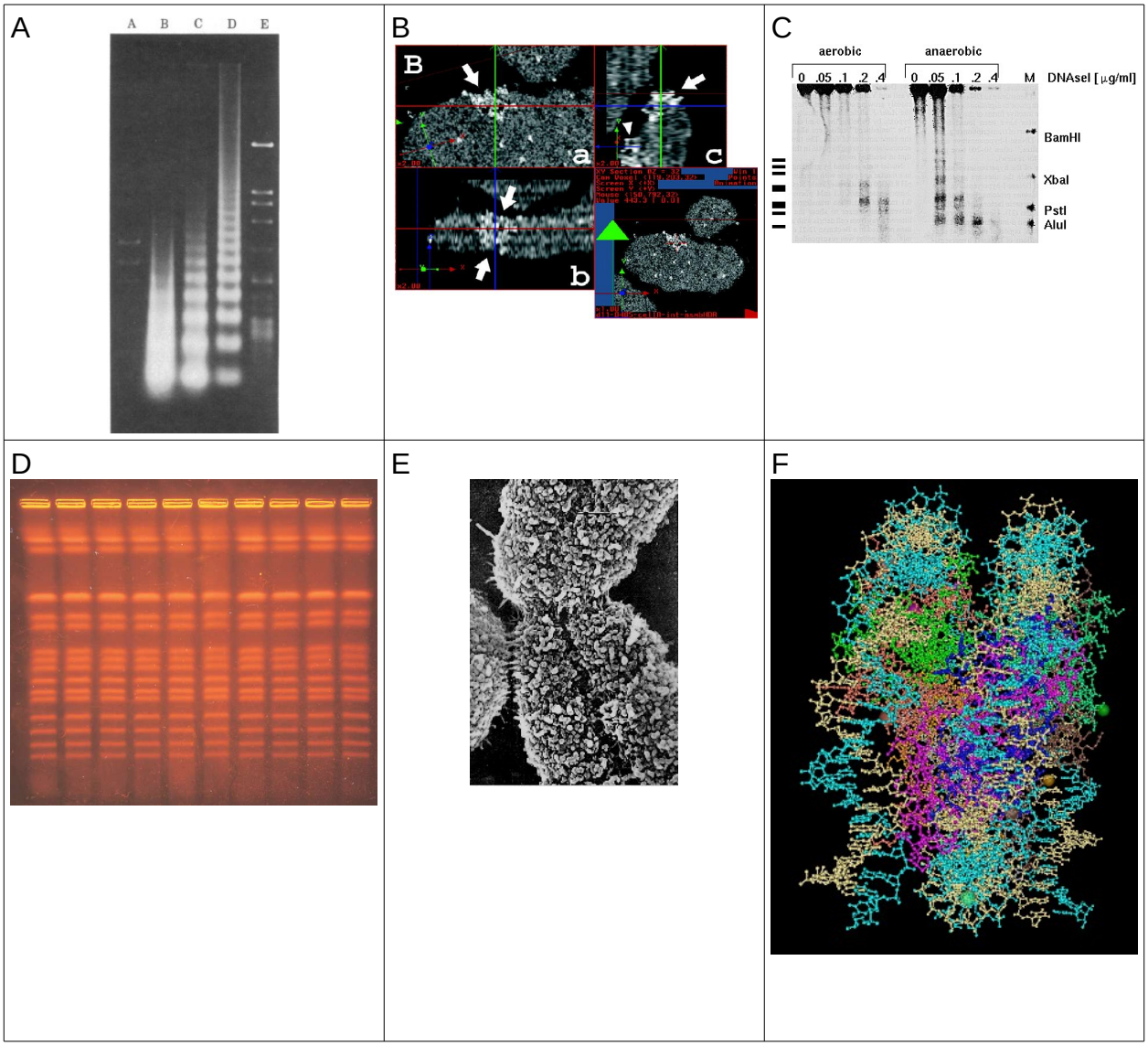


Both the genetic ratio and the FISH results point to the same conclusion. What is that conclusion?

6. (10 points) Briefly describe the function of the substage condenser on a microscope. Draw a diagram to illustrate how it accomplishes this function.

7. (10 points) Each eukaryotic chromosome has numerous origins of replication. What is the advantage of having multiple origins of replication in eukaryotic chromosomes? Draw a diagram to illustrate your discussion.

8. (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.



I. The eukaryotic chromosome is a single DNA molecule.

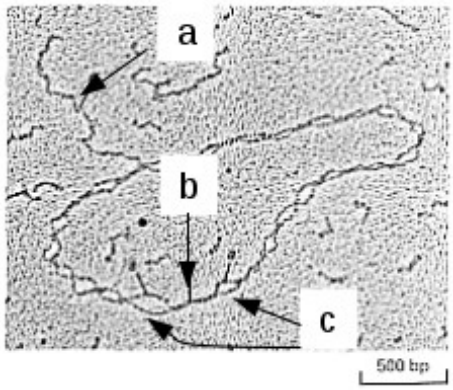
II. At least in some chromosomes, there are at least two higher-order levels of chromatin folding/coiling, between the domain level of organization, and the final mitotic chromosome.

III. DNA is associated with chromatin proteins in units with a periodicity of about 200 bp.

IV. The DNA double helix wraps twice around the nucleosome core particle.

V. Transcriptionally active genes have a more open chromatin conformation than inactive genes.

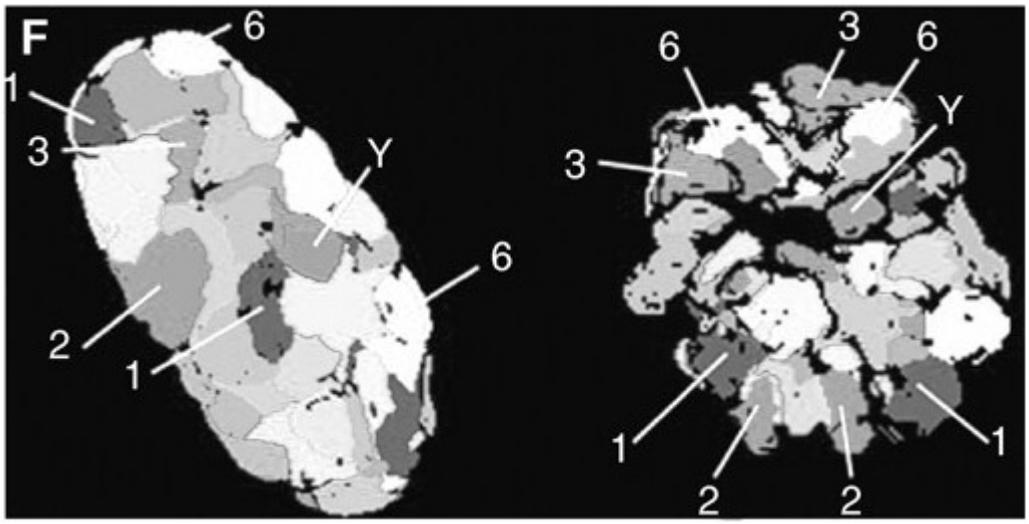
9. (5 points) In the figure at right, circular SV40 DNA is shown from a psoralen-UV crosslinking experiment in which nucleosomal DNA was protected from crosslinking, while the spacer DNA between nucleosomes was not protected.



Which letters refer to

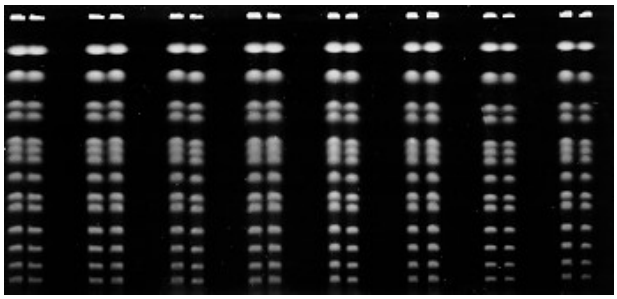
- an RNA transcript
- single-stranded DNA
- double-stranded DNA

10. (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.

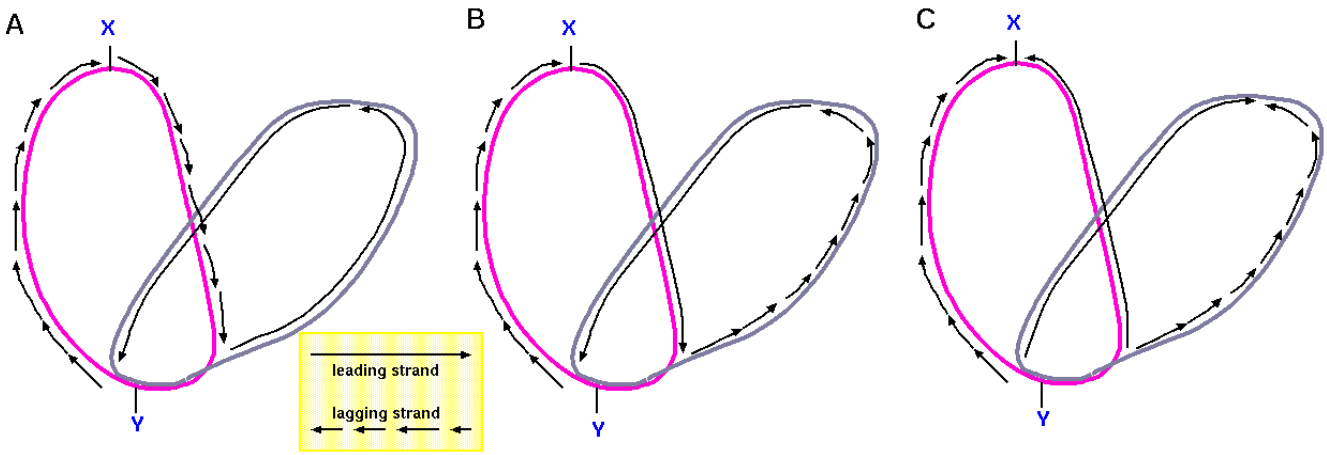


11. (5 points) The figure below shows Pulsed Field Gel Electrophoresis (PFGE) of yeast (*Saccharomyces cerivisciea*) chromosomal DNA. Each band corresponds to a chromosome, and the sizes of the chromosomes are all known.

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?



12. (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?

13. (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?