PLNT3140 INTRODUCTORY CYTOGENETICS

MID-TERM EXAMINATION

1 p.m. to 2:15 p.m. Thursday, October 20, 2022

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 14 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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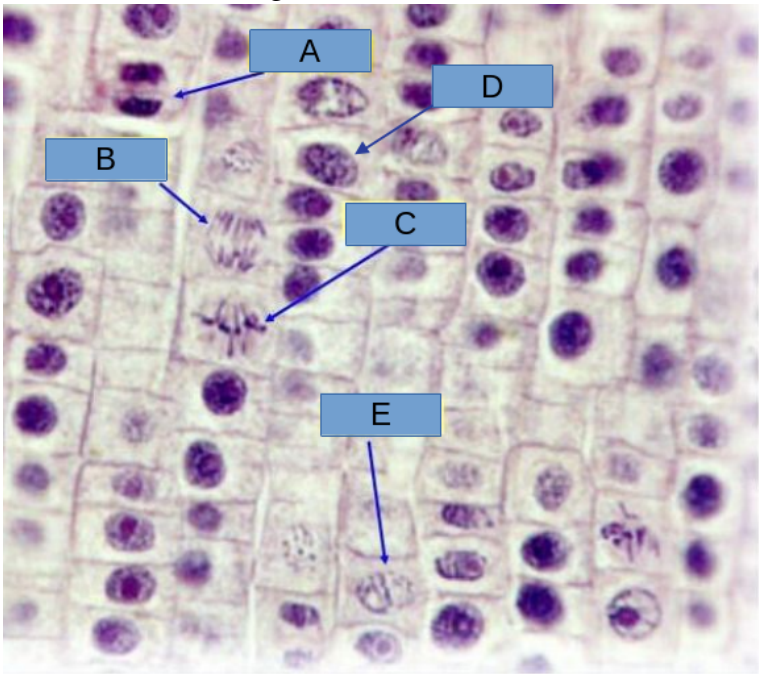
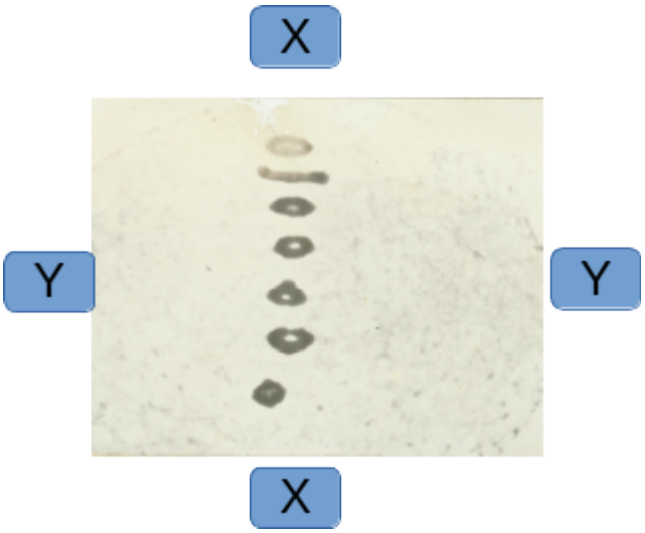
1. (5 points) In the Mitosis lab, one of the effects of treatment with 1N HCl would be to break down cellulose in plant cell walls. How would that help in getting good cells to view under the microscope?

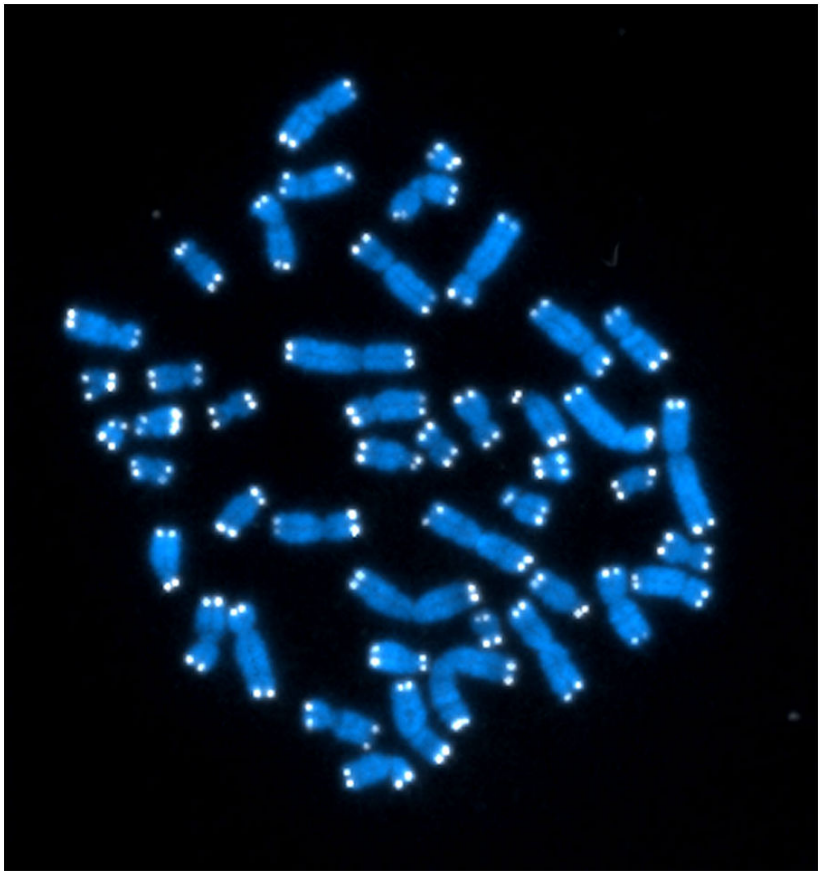
2. (10 points) For A - E, indicate the stage of mitosis.



3. (5 points) Which is the location of the centrosomes, X or Y?



4. (5 points) The figure shows FISH results using a telomeric sequence as a probe of human metaphase chromosomes.



Which hypothesis is best supported by the data:

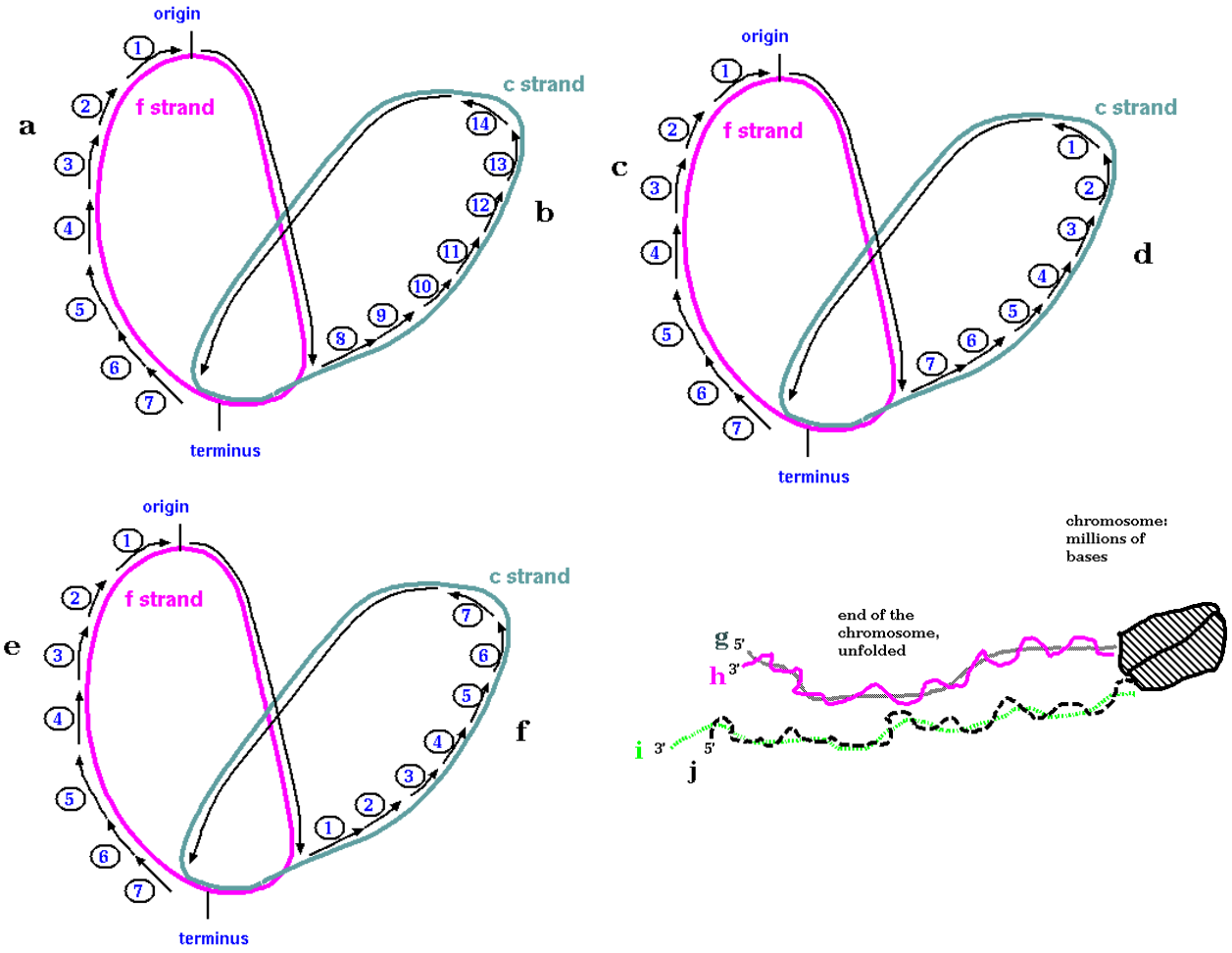
a - All chromosomes use the same telomeric repeat sequence

b - Different chromosomes have different telomeric repeats.

c - All telomeres are the same length

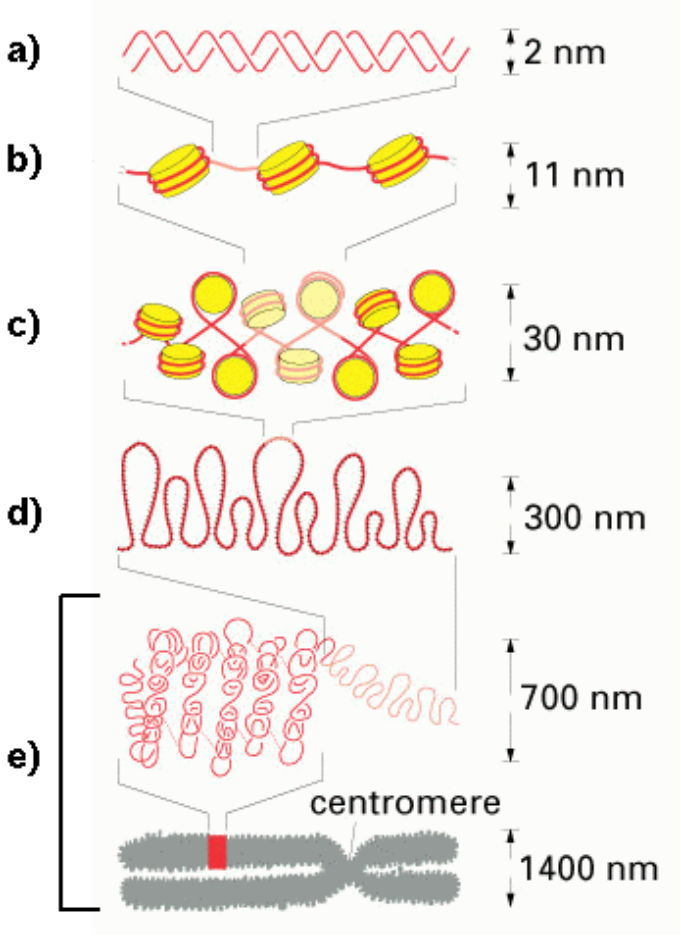
d - Telomeres protect chromosome ends from degradation.

5. (10 points) Three diagrams illustrating bidirection replication of a circular DNA are shown. In each diagram, the order of synthesis of Okazaki fragments is indicated. For a - f, indicate whether the order is correct or incorrect. Also shown is a diagram of DNA from two sister chromatics after replication. For each strand labeled g - j, indicate whether the strand is one of the original template strands, or a newly-synthesized strand.

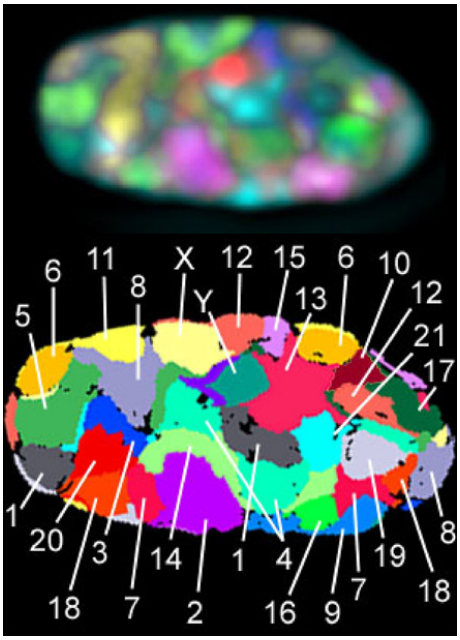


a
b
c
d
e
f
g
h
i
j

6. (10 points) The figure below summarizes steps in chromatin packaging. Based on experiments described in the course so far, which steps exhibit what we now know to be inaccuracies? Explain your reasoning.



7. (10 points) In the figure at right, we see an interphase diploid nucleus in which each chromosome has been painted with a specific combination of fluorescent tags. A series of images was acquired, each at a different focal plane within the nucleus. We are seeing only one of those focal planes. At bottom is an interpretation of the image, showing the locations of different chromosomes.



a)For some chromosomes, we see both copies, while for others, we see only one copy of a chromosome. What is the reason we can't see both copies?

b) Is the area occupied by a chromosome in this 2-D image a good indicator of the actual volume of the chromosome, or of its length?

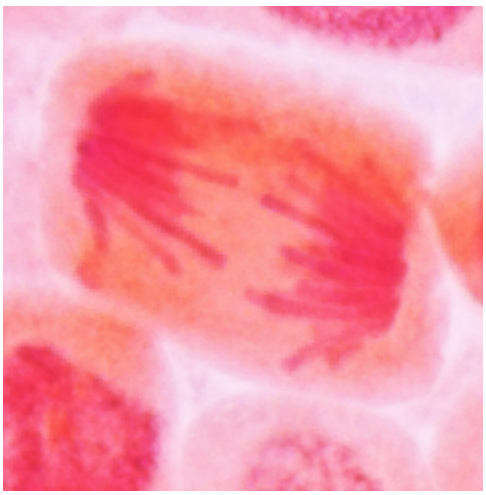
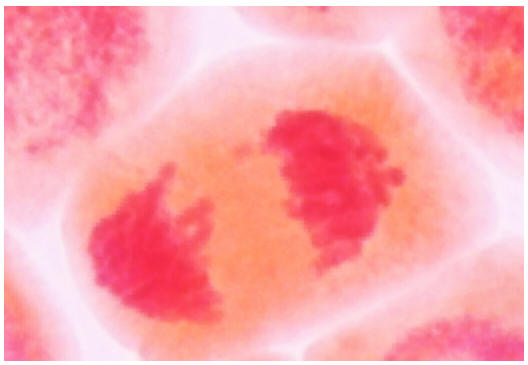
8. (10 points)The Drosophila melanogaster and human genomes are compared in the table below.

	Drosophila melanogaster	Homo sapiens
haploid complement	3 autosomes + 1 XY pair = 4 chromosomes	22 autosomes + 1 XY pair = 23 chromosomes
Total length of haploid genome	1.38×10^8 bp	3×10^9 bp

a) Ignoring crossing over, does meiosis in Drosophila generate more genetic diversity, or less, compared to meiosis in humans? Give calculations to support your answer.

b) Next, consider the contribution of crossing over to genetic diversity. Would you expect crossing over to be a more effective mechanism for generating genetic diversity in Drosophila compared to human? Give a calculation to support your answer.

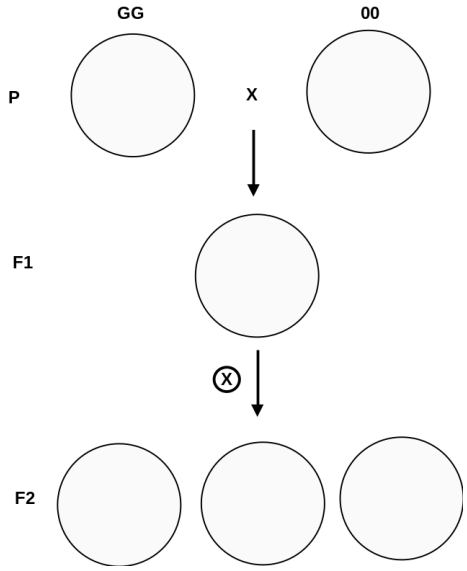
9. (10 points) The appearance of chromosomes during anaphase is the result of the kinetochores "climbing" along the spindle fibers toward the centrosomes, while the arms lag behind.

Early anaphase	Late anaphase
	

While we haven't gone into a lot of detail about telophase, one possibility is that chromosomes largely stay in place, after reaching the opposite poles, and that telophase proceeds by uncoiling of chromosmes where they are, and reforming the nuclear envelope around them. In other words, this model predicts that by the end of telophase or the beginning of G1, chromosomes will be in essentially the same orientation and relative locations that they were in late in anaphase.

Given fluorescent hybridization probes for centromeric and telomeric sequences, how could you use those probes to test that hypothesis? Draw a diagram showing the expected FISH results look like if that hypothesis were true.

10. (10 points) Suppose you have a transformed plant which is homozygous for insertion of a foreign gene into one of the chromosomes. You cross the transformant line with a plant lacking the transformant gene. That cross could be represented as GG x 00, where G represents a transformant chromosome, and 0 represents a chromosome lacking the gene. In the diagram below, nuclei are represented as circles.
a) Re-draw that diagram showing expected FISH results, using a probe for gene G.
b) What would be the ratio of progeny seen in the F2 generation?



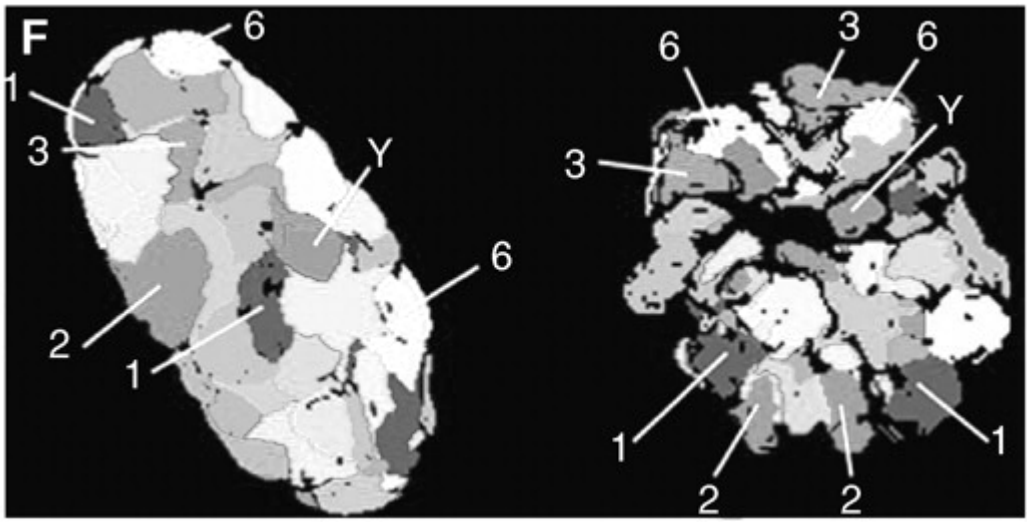
11. (5 points) Eukaryotes generally have linear chromosomes. Is it impossible to have circular chromosomes in eukaryotes? Give evidence to support your reasoning.

12. (10 points) We have demonstrated that if you do a restriction digest of genomic DNA from any eukatyotic genome, you get smear of DNA on the gel, because there are so many bands that they cannot be resolved as separate bands. Would the same be true of a prokaryotic genome?

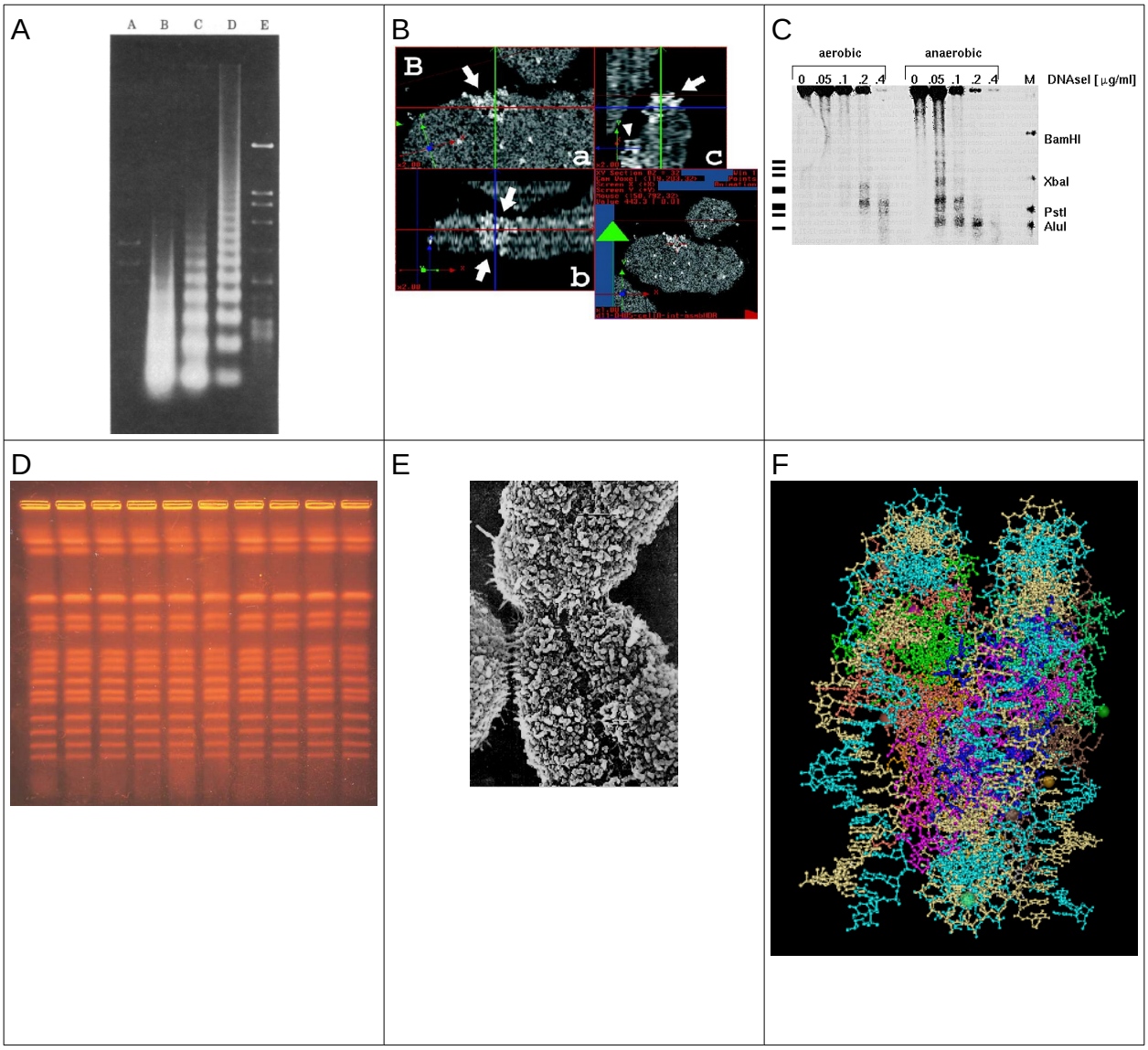
a) For example, consider a restriction digest of E. coli (genome size = 5.5×10^6 bp) digested with any enzyme that recognizes a 6 base sequence (eg. BamHI, HindIII, EcoRI). Do a calculation to answer this question.

b) What if you used an restriction enzyme that recognizes an 8 base sequence (eg. NotI). Do a similar calculation to demonstrate whether or not an 8-cutter would improve the result.

13. (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.



14. (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.