

PLNT3140 INTRODUCTORY CYTOGENETICS

MID-TERM EXAMINATION

1 p.m. to 2:15 p.m. Tuesday, October 20, 2020

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 15 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.

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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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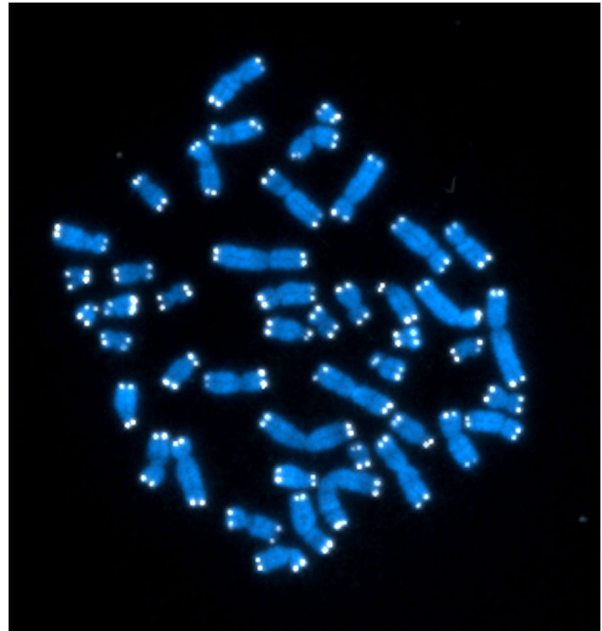
1. (10 points) Most crops are propagated through sexual crosses. Bananas are an example of a crop that is propagated asexually by planting cuttings from mature plants. This is necessary because commercial banana varieties employ female sterility to give seedless fruit. How would genetic diversity in 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?

2. (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?

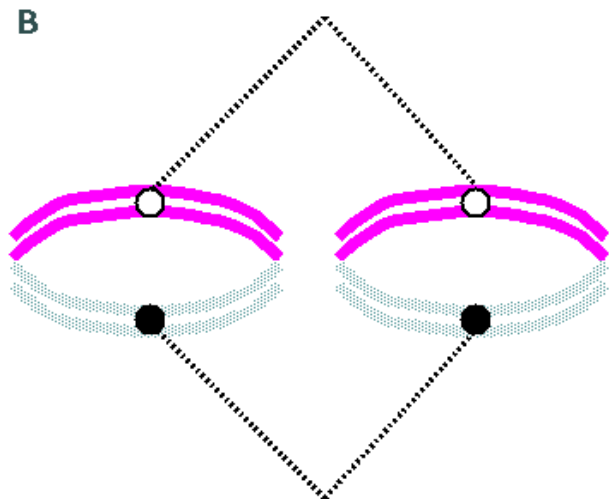
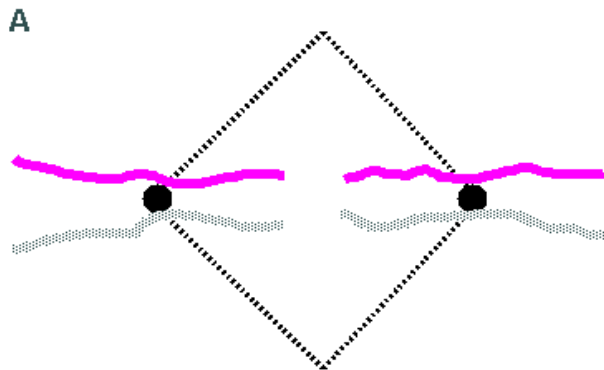
3. (5 points) The following diagram shows the DNA sequence of a human telomere. Write out sequence of the RNA carried by the human telomere terminal transferase. Make sure to label the 5' and 3' ends of the RNA.

5 ' CCCTAACCCCTAA -----  
3 ' GGGATTGGGATTGGGATTGGGATT -----

4. (5 points) The image shows a mitotic chromosome spread in which chromosomes were FISH. What was the identity of the FISH probe that was used? Cite evidence to support your conclusion.

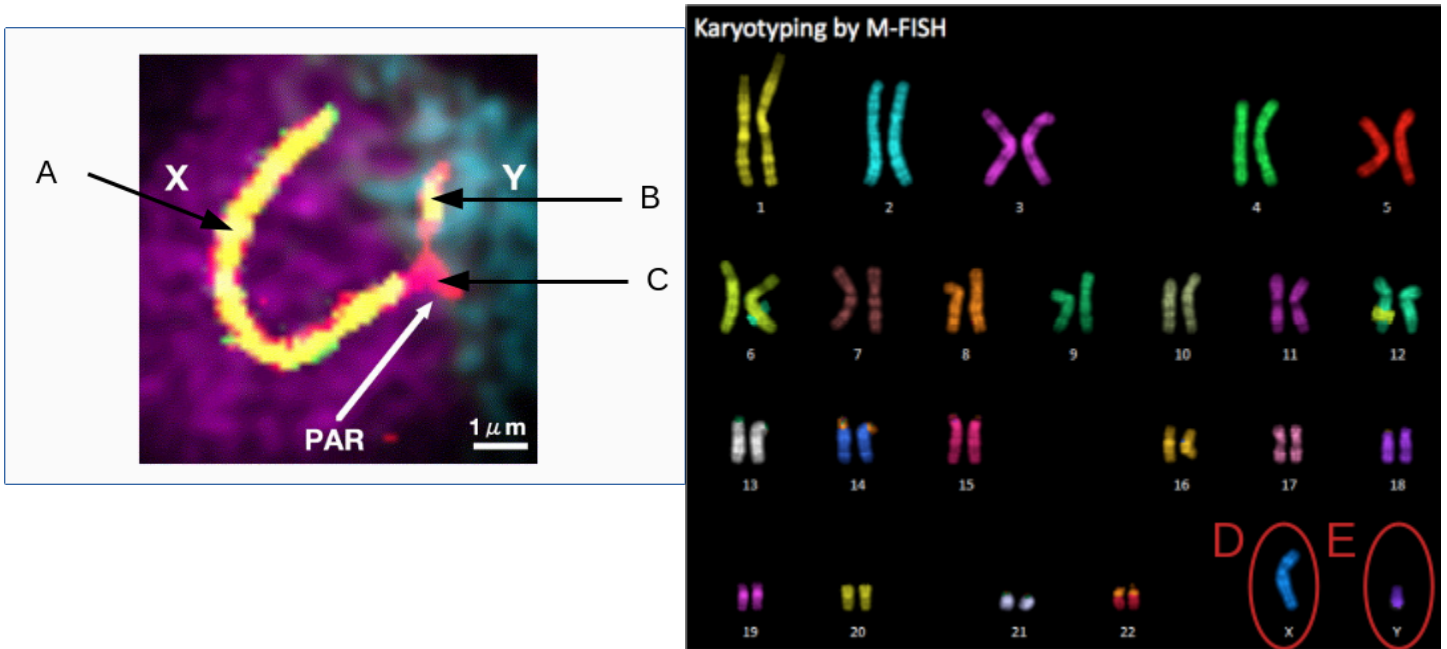


5. (10 points) One of the diagrams below illustrates meiotic metaphase I, and the other illustrates mitotic metaphase I. Based on what you know about mitosis and meiosis, which one is A, and which one is B? Explain your choice.



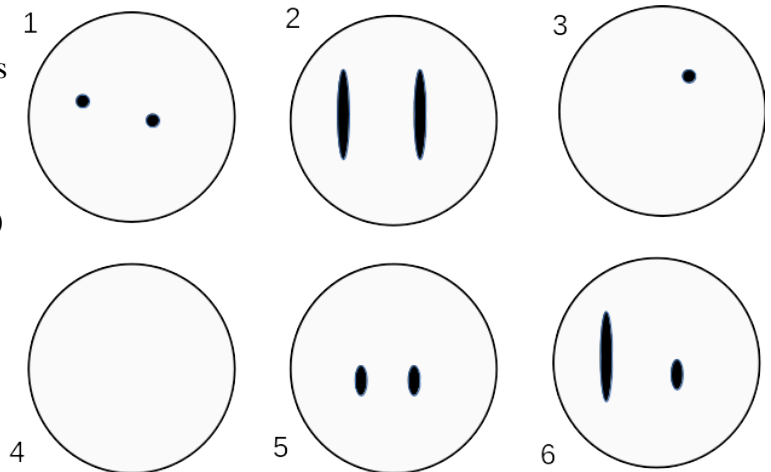
6. (15 points) Multiple Selection

Suppose you had five hybridization probes available for FISH. Probes A - C are 21 nt oligonucleotide probes from regions of the human X and Y chromosomes, as indicated at left. Probes D and E are chromosome painting probes, as illustrated at right.



Diagrams of predicted hybridization results are illustrated at right. For many of the reasons discussed in class, the size and shape of FISH signals in nuclei are not easy to estimate in 2 dimensions. For simplicity, assume that all signals are either long or short (eg. #2, 5 or 6) or a single dot (eg. #1 or 3).

For each of the probes A - E in cells from males or females, Using a table similar to the one below, indicate which hybridization pattern (1 - 6) would be seen.

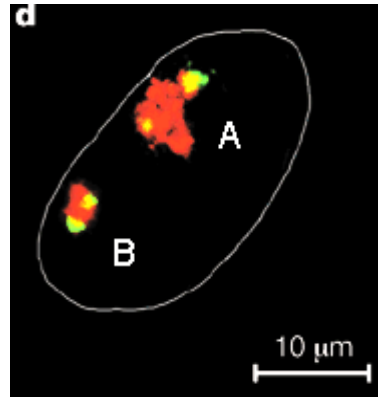


|        | probe |   |   |   |   |
|--------|-------|---|---|---|---|
|        | A     | B | C | D | E |
| Male   |       |   |   |   |   |
| Female |       |   |   |   |   |

7. (5 points) Imagine that you have two ropes tangled together. You grab in the middle and start pulling the ropes apart. As they come apart, it gets harder to pull on them. Finally, the tangles form a single knot at one end. You give the ropes one strong tug and they come apart.

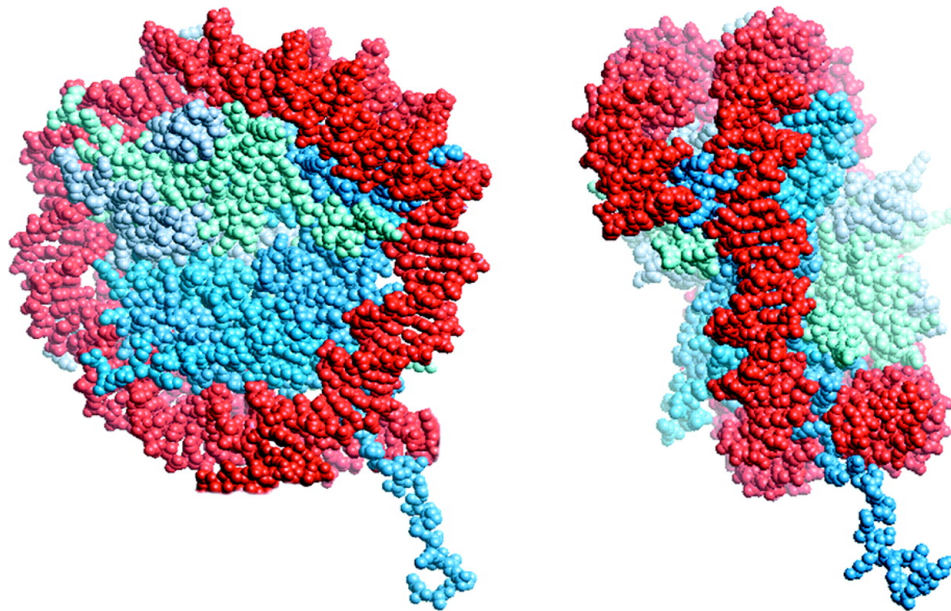
Name the stage of meiosis to which this rope analogy applies.

8. (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.



9. (5 points) The rye genome has 7 chromosome pairs. Ignoring crossing over, how many distinct gametes can be produced by Mendelian segregation during meiosis?

10. (5 points) A 3D 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 among widely diverged taxa like plants and animals?

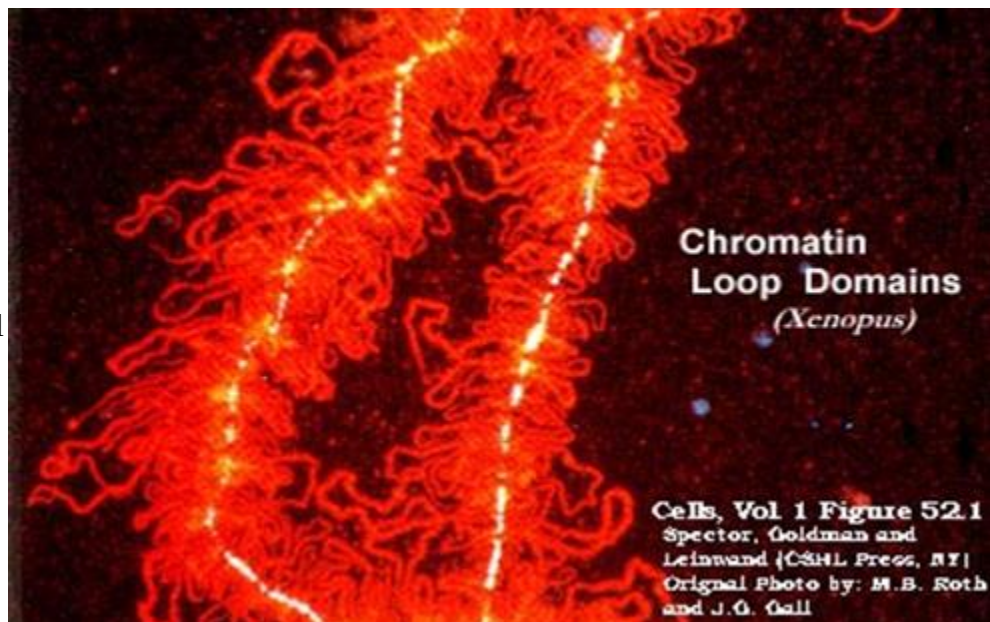


11. (5 points) Fill in the blanks:

In the Tree of Life diagram, the eukaryotes diverged from prokaryotes, and then split into four main groups: protists, fungi, animals and plants. However, there is a single thin line connecting early bacteria to the common ancestor of all eukaryotes (enhanced using a red dotted line). This line represents \_\_\_\_\_ .



12. (10 points)The figure at right shows a "lampbrush" chromosome from *Xenopus* oocytes during meiotic metaphase I. The strong yellow signal is from fluorescently labeled antibodies to Topoisomerase II. What does this observation tell us about the chromosome scaffold, and the mechanism by which chromatin structure controls gene expression? Why are lampbrush chromosomes so unusual for cells at meiotic metaphase I?



13. (10 points)

During Prophase, \_\_\_\_\_ a \_\_\_\_\_ ends of spindle fibers extend from the centrosomes by polymerization of \_\_\_\_\_ b \_\_\_\_\_ subunits. Polymerization is halted if a spindle fiber complexes with proteins at the \_\_\_\_\_ c \_\_\_\_\_. The \_\_\_\_\_ c \_\_\_\_\_ proteins bind to a locus on the chromosome known as the \_\_\_\_\_ d \_\_\_\_\_. At anaphase, chromosomes migrate toward the centrosomes by \_\_\_\_\_ e \_\_\_\_\_ of the spindle fibers. As chromosomes migrate toward the poles, \_\_\_\_\_ e \_\_\_\_\_ of the spindle fibers provides the energy needed to move the chromosomes.

14. (10 points) Matching.

As we discussed in class, cells in culture grow asynchronously, meaning that they divide at different times. In order to study the cell cycle, one can incubate cells with colchicine, arresting cells at metaphase, until all cells catch up, and are at metaphase. Once cells are transferred to fresh media without colchicine, cell division resumes. Cells are then said to be growing in synchronous culture because they go through the different stages of the cell cycle at the same time.

In an experiment cells were grown either in synchronous or asynchronous culture. Both RNA synthesis and DNA synthesis were measured in each stage or mode of growth. Measurements are on an arbitrary scale from 0 (minimum) to 1 (maximum).

Match each cell cycle stage or mode of growth with the result in the table most likely to be observed. Each of the 5 results will match 1 of the 5 conditions.

|   | RNA synthesis | DNA synthesis |
|---|---------------|---------------|
| a | 1             | 0.1           |
| b | 0             | 0             |
| c | 0.5           | 0             |
| d | 1             | 1             |
| e | 1             | 0             |

Stage or mode of growth:

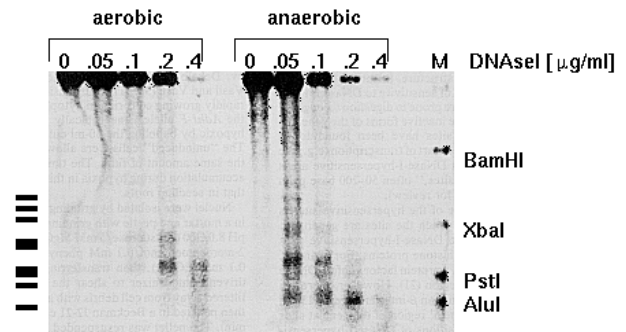
- G1
- S
- G2
- M
- asynchronous culture

15. (10 points) Match each picture with one of the following sentences.

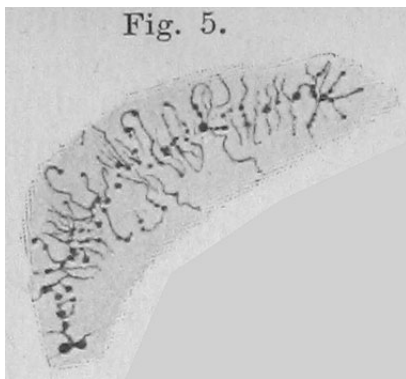
A.



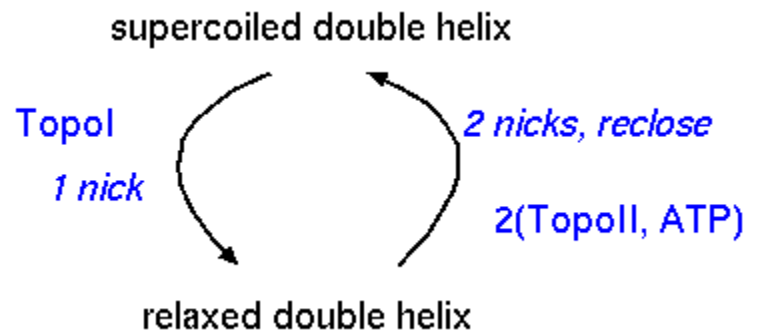
B.



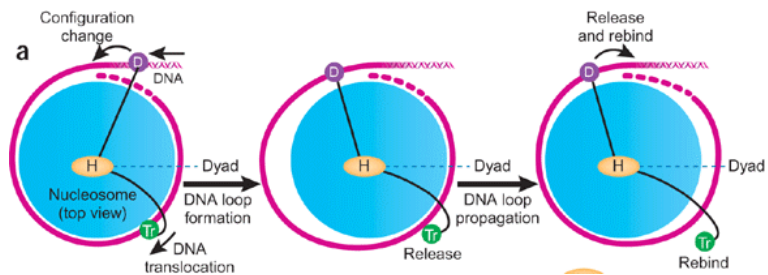
C.



D.



E.



1. Energy is required to coil a chromatin domain, while energy is released when a chromatin domain opens up.
2. A chromatin domain is formed by the attachment of DNA to nuclear matrix proteins
3. In isolated nuclei, nucleosome structure protects DNA from digestion by DNaseI.
4. The higher-order folding of chromosomes is non-uniform in different regions of the chromosome.
5. Transcription can occur even when DNA is complexed into nucleosomes.