

PLNT3140 INTRODUCTORY CYTOGENETICS

MID-TERM EXAMINATION

1 p.m. to 2:15 p.m. Tuesday, October 19, 2021

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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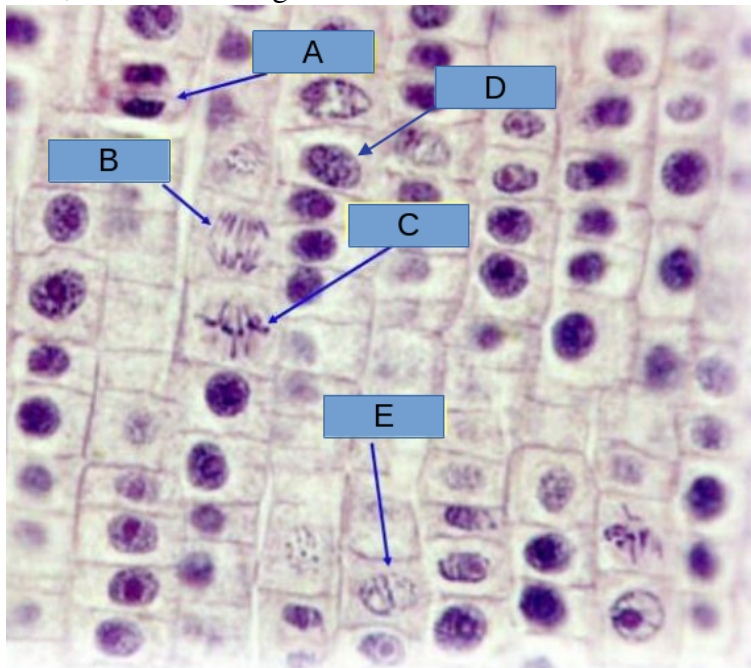
Ways to write a readable and concise answer:

- 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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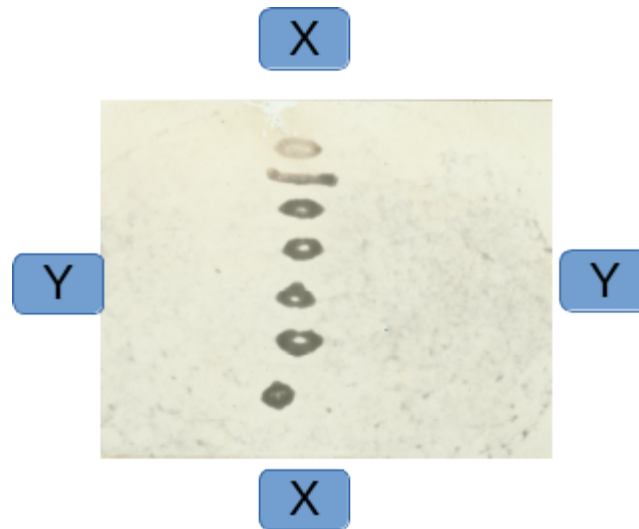
1. (5 points) Imagine that you have two ropes tangled together. You grab in the middle and start pulling the ropes apart. As they come apart, it gets harder to pull on them. Finally, the tangles form a single knot at one end. You give the ropes one strong tug and they come apart.

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

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



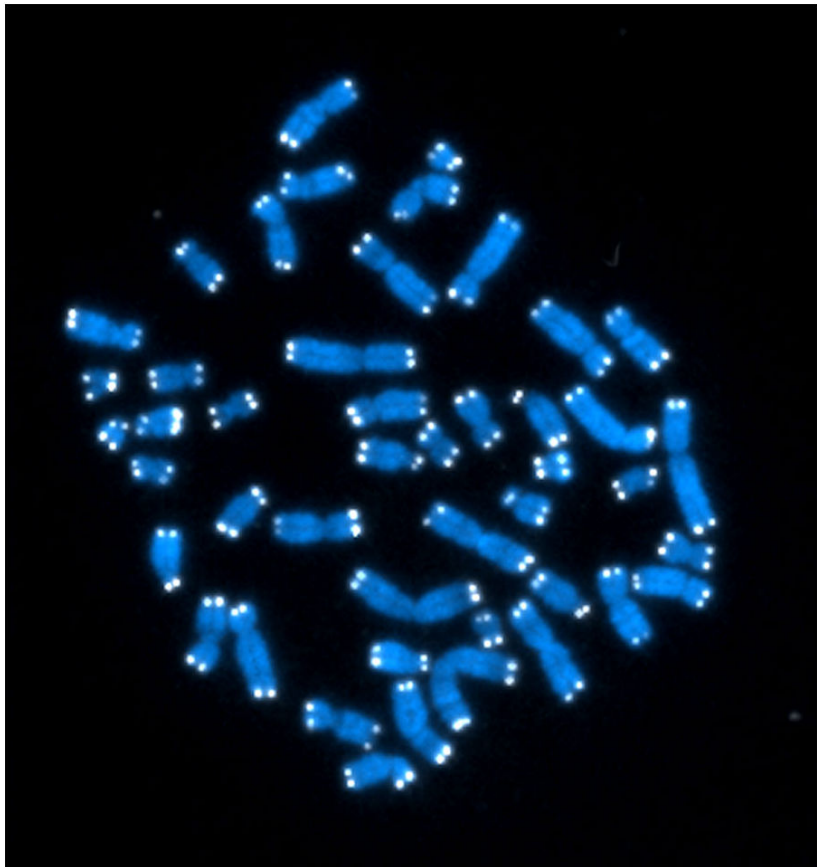
3. (5 points) Which is the location of the centrosomes, X or Y?



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

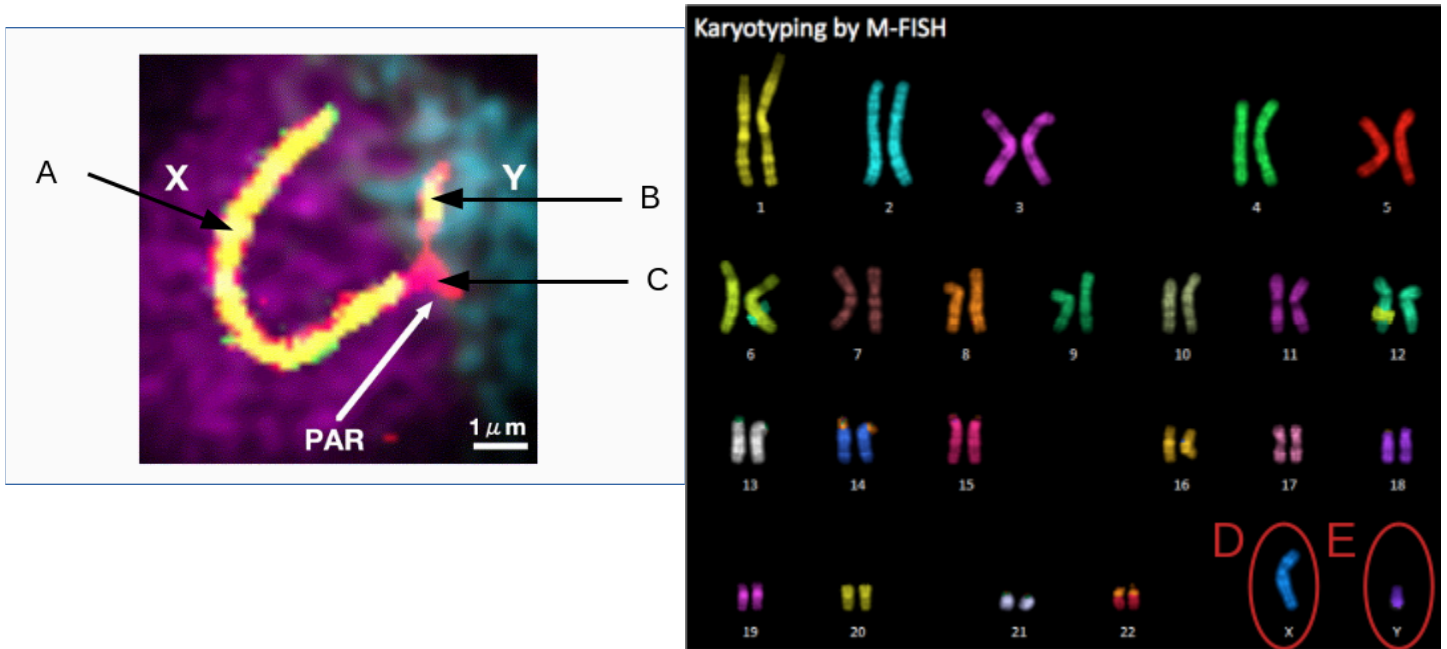
Which hypothesis is best supported by the data:

- 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.



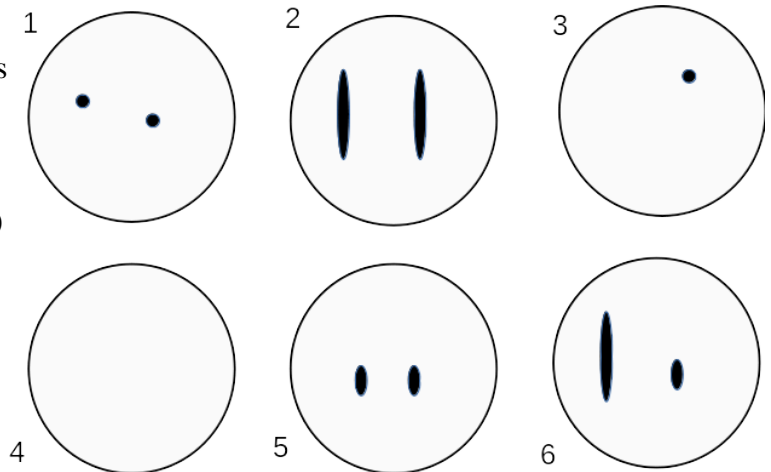
5. (20 points) Multiple Selection

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.



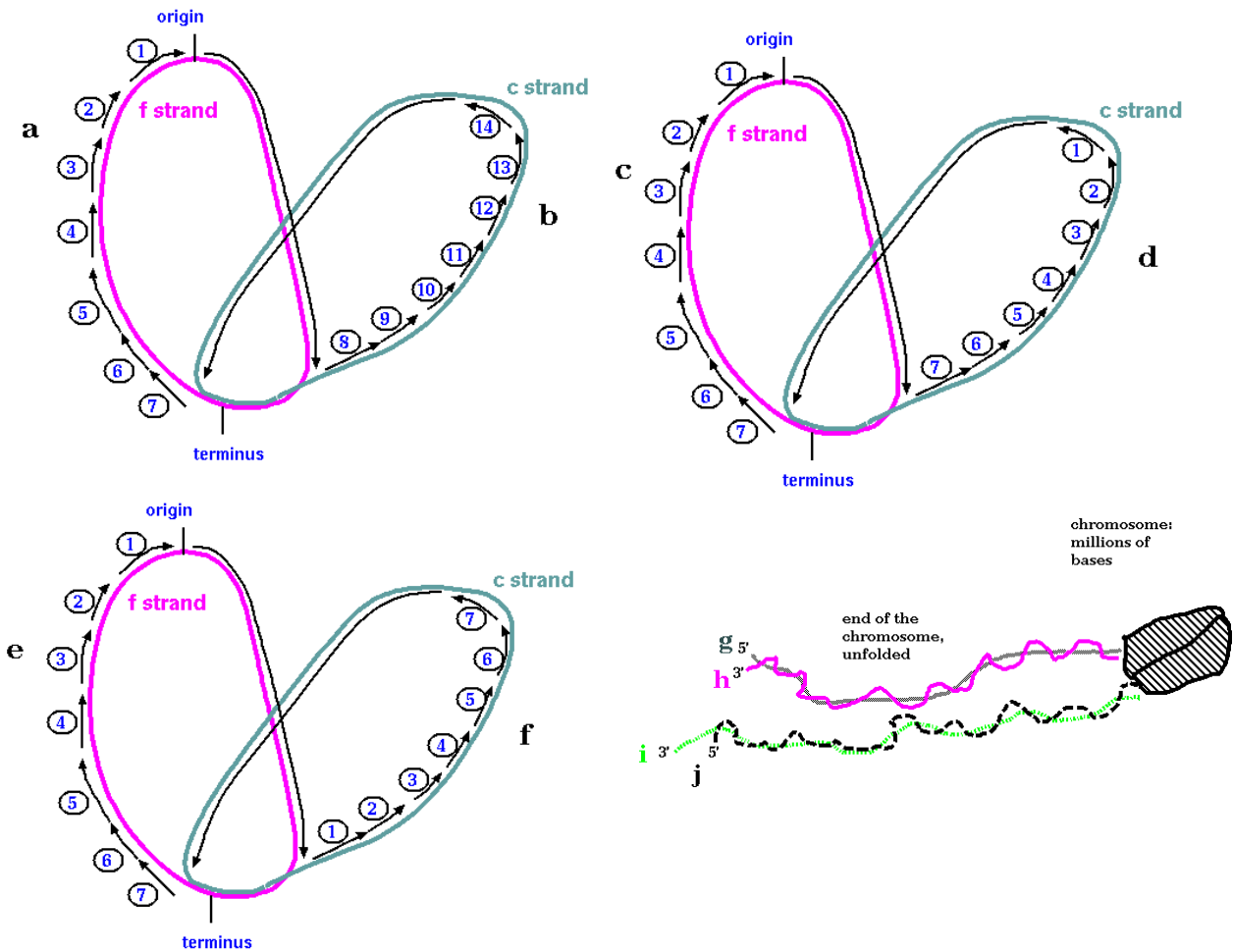
Diagrams of predicted hybridization results are illustrated at right. For many of the reasons discussed in class, the size and shape of FISH signals in nuclei are not easy to estimate in 2 dimensions. For simplicity, assume that all signals are either long or short (eg. #2, 5 or 6) or a single dot (eg.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

6. (10 points) Three diagrams illustrating bidirectional 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 chromatids after replication. For each strand labeled g - j, indicate whether the strand is one of the original template strands, or a newly-synthesized strand.



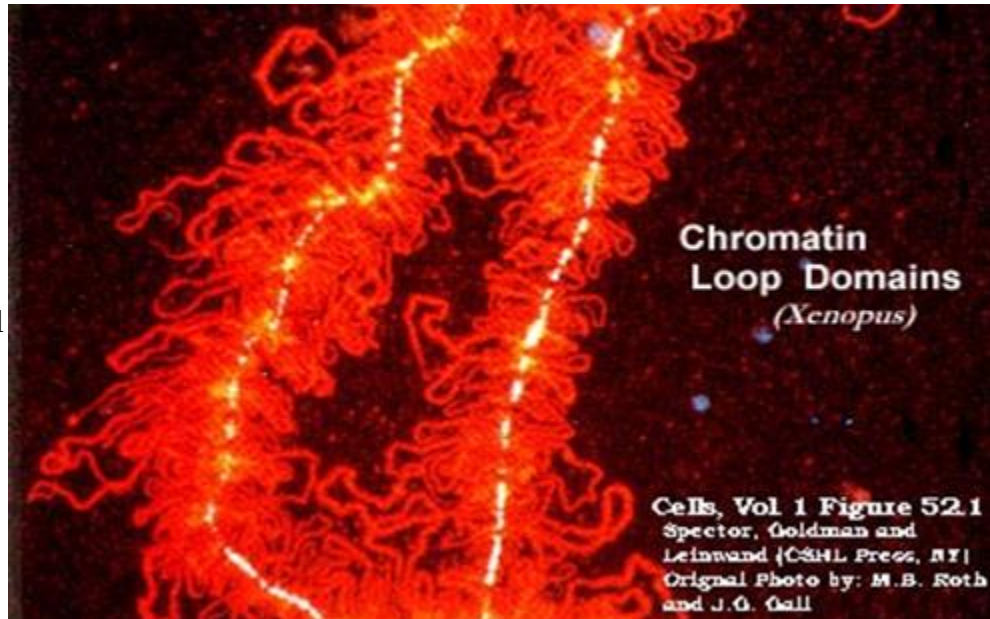
- a
- b
- c
- d
- e
- f
- g
- h
- i
- j

7. (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 \_\_\_\_\_ .



8. (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?

9. (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.

10. (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:

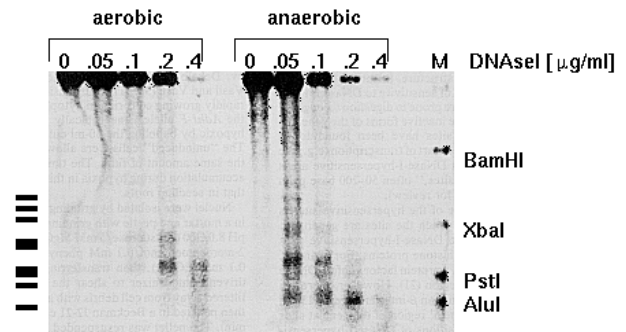
- G1
- S
- G2
- M
- asynchronous culture

11. (10 points) Match each picture with one of the following sentences.

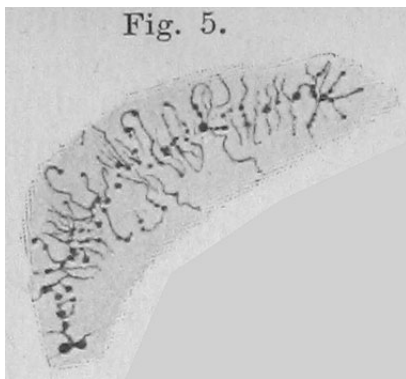
A.



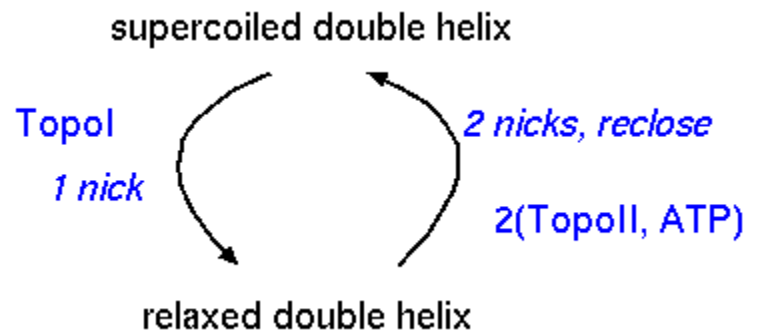
B.



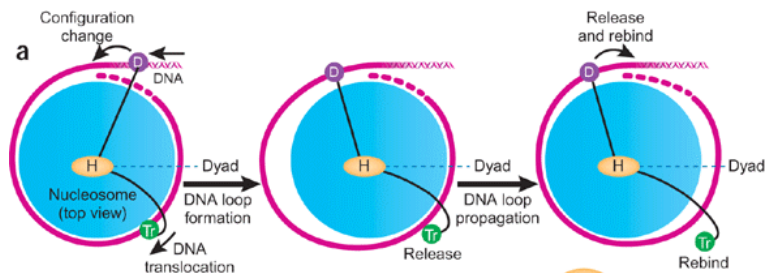
C.



D.



E.



1. Energy is required to coil a chromatin domain, while energy is released when a chromatin domain opens up.

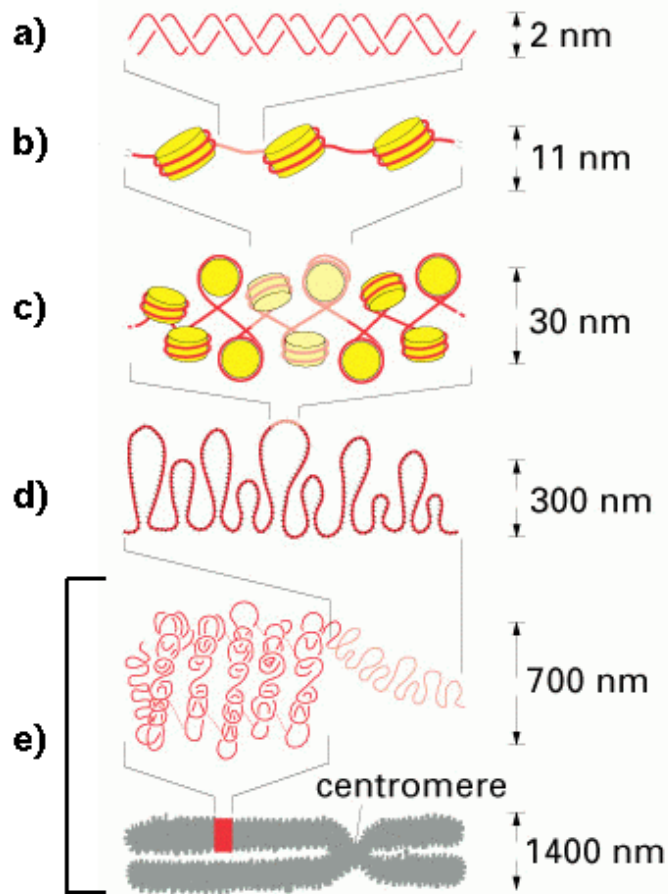
2. A chromatin domain is formed by the attachment of DNA to nuclear matrix proteins

3. In isolated nuclei, nucleosome structure protects DNA from digestion by DNaseI.

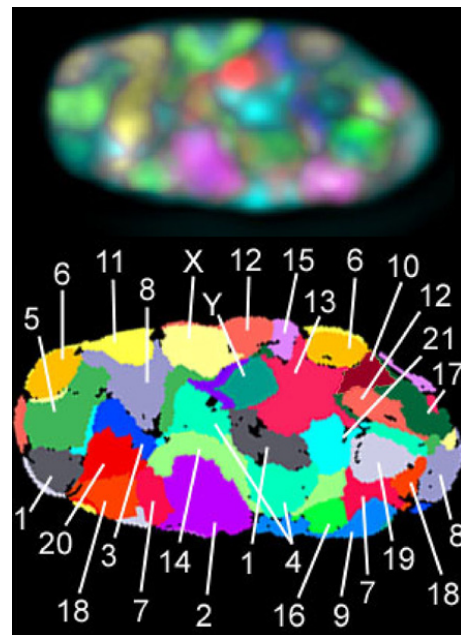
4. The higher-order folding of chromosomes is non-uniform in different regions of the chromosome.

5. Transcription can occur even when DNA is complexed into nucleosomes.

12. (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.



13. (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?