

39.314 INTRODUCTORY CYTOGENETICS

MID-TERM EXAMINATION

1 p.m. to 2:20 p.m. Tuesday, October 30, 2001

This examination is worth 20% of the course grade. There are 8 questions totalling to 100 points.

Hand in these question sheets along with your exam book.

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1. (5 points) The figure below shows chromosomes that are mitotic, rather than meiotic. What about this picture supports that assertion?



2. (5 points) Aside from the need from crossing over, why is chromosome pairing an essential part of meiosis?

3. (15 points) Each statement below contains an error. For each statement, indicate which part is incorrect, and how the correct statement should read.

Example: A single unit of replication is referred to as a leprechaun.

*your answer might be*

... is referred to as a replicon.

a) Matrix Attachment Regions, when included in gene constructs transformed into plants, confer a higher level of transcription for the population of transformants, compared to transformants without MARs.

b) The “default” state of chromatin in the nucleus is a solenoid of 10 nm as observed in

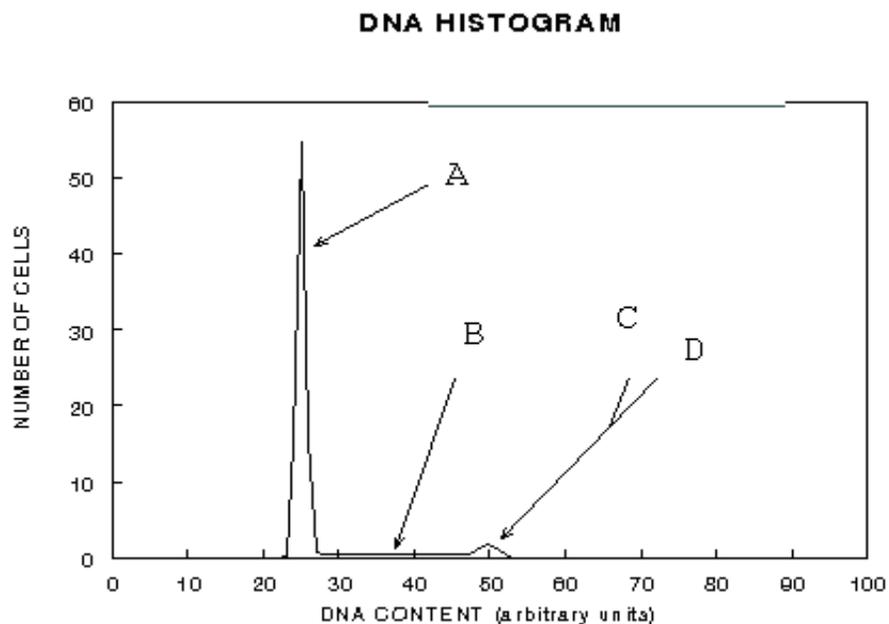
electron microscopy.

c) The lampbrush chromosomes of salamander oocytes provide an unusual example of DNA synthesis during meiotic prophase I.

d) Loops of chromatin are joined to the nuclear matrix at intervals of about 50 kb forming discrete domains which uncoil when inactive and are condensed to facilitate gene expression.

e) Replication origins tend to be GC rich, which makes it easier to open the helix for access by DNA polymerase complexes.

4. (15 points) The diagram below presents data from a cell-culture experiment. The DNA content of cells was measured, and the number of cells with a given amount of DNA were plotted on the graph. Note that B refers to the entire region between A and C,D.



a) Why are most cells in fraction A? What stage of the cell cycle does A represent?

b) What stage of the cell cycle is B? Why does it cover a wide range of DNA amount per cell.

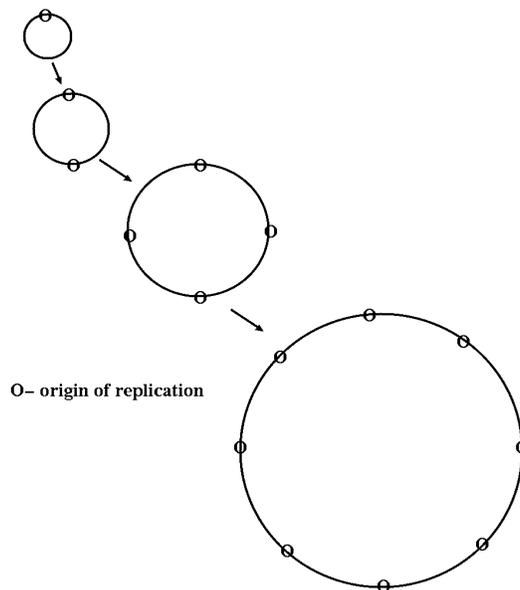
c) What stages of the cell cycle are represented by C and D?

5. (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?



6. (20 points) Describe the key events occurring in each of the 5 stages of Meiotic Prophase I listed below. Use no more than two sentences for each.

- a) Leptotene
- b) Zygotene
- c) Pachytene
- d) Diplotene
- e) Diakinesis

Extra credit (5 points): It has been observed that a small amount of DNA synthesis occurs at pachytene. What might be the reason?

7. (15 points)

- a) Which part of the DNA molecule confers the net negative charge?
- b) Which components of histone proteins confer a net positive charge?
- c) What is the significance of a) and b) ?

8. (10 points) DNaseI hypersensitive sites in genes can be mapped to a resolution of a few base pairs. What does this imply as to the level of chromatin structure that is being probed by this method (eg. Nucleosome structure, solenoid structure, chromatin domains, higher-order packaging)?