PLNT3140 INTRODUCTORY CYTOGENETICS

# MID-TERM EXAMINATION

1 p.m. to 2:15 p.m. Tuesday, October 20, 2015

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.

Hand in these question sheets along with your exam book.

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1. (20 points) Create a table, similar to the one below. For both prokaryotes and eukaryotes, cite at least two characteristics for each of the five categories given. (You can't just restate the same concept twice in different words.)

| | Prokaryotes | Eukaryotes |
|---|---|---|
| Taxonomic groups | | |
| Cell biology | | |
| Genome structure | | |
| Gene expression | | |
| Cell cycle | | |

2. (10 points) Fill in the blanks. Just provide terms for a - e. You don't need to restate all of the text.

- Two conflicting goals in evolution:
  - accurately replicating the organism and its genome
  - generating genetic diversity to drive evolution
- Meiosis
  - ensures that all gametes receive _____a_____
  - generates genetic diversity through _____b_____ and _____c_____
- The nucleus is
  - the "hard drive" of the cell, essentially, a database of all genetic information
  - a mechanical and biochemical device optimized both for
    - _____d_____
    - accurate transmission of genetic information into the next cell generation
- Major changes in genome structure drive _____e_____ by creating reproductive barriers between subpopulations

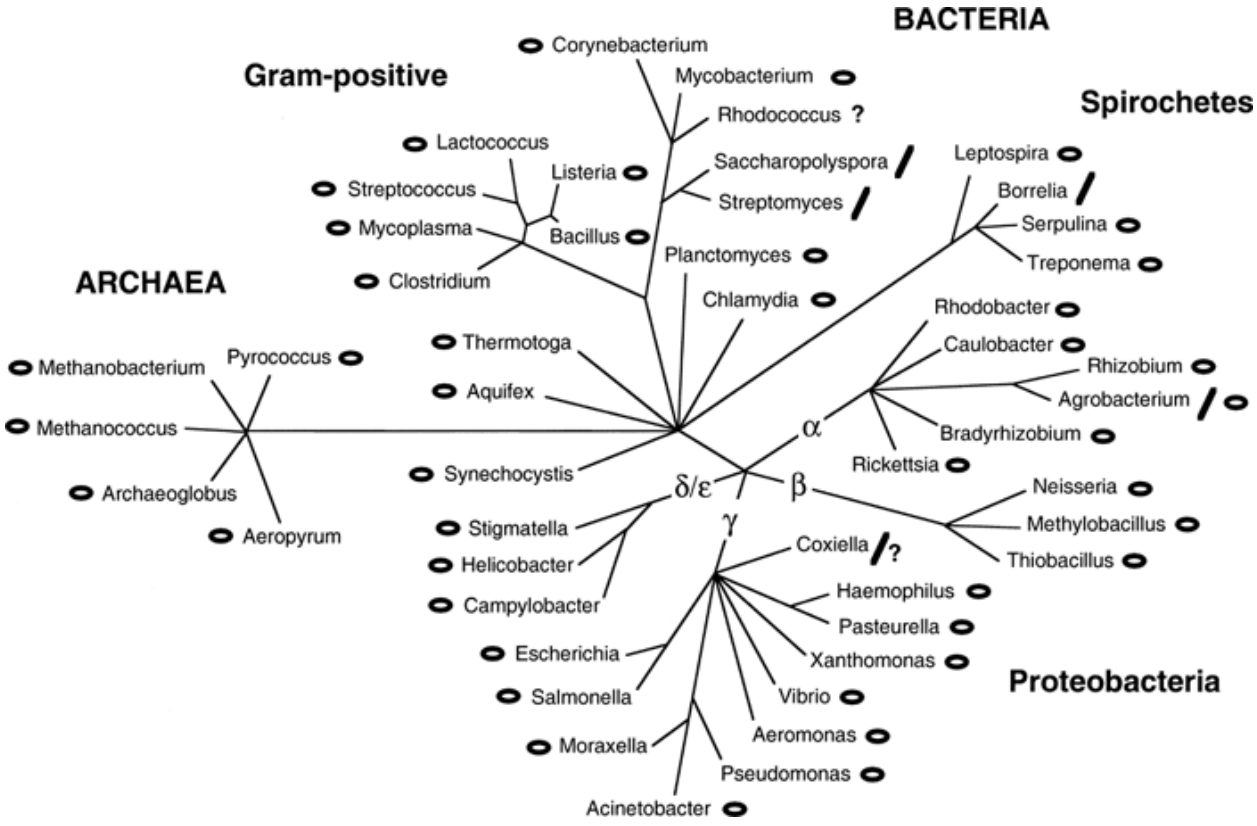
3. (5 points) Spindle fibers are microtubules, hollow rods formed from dimers of alpha- and beta-tubulins. A hollow rod is known by engineers to be a rigid structure, able to bear a lot of force for a small investment in mass. Considering the function of polar spindle fibers, why is it essential that the polar spindle be a rigid structure?

4. (10 points) Telomeres in most eukaryotes are composed of single-stranded tandem repeats of short repeat units. Some examples include:

| | |
|---|---|
| *Oxytricha* | *5*'$C_4A_4$3' |
| *Saccharomyces* | 5'$C_{2-3}A(CA)_{1-3}$3' |
| *Dictyostelium* | *5*'$C_{1-8}$T3' |

Why do telomeres consist of short repeats? In other words, how do these short repeats contribute to the two main functions of telomeres?

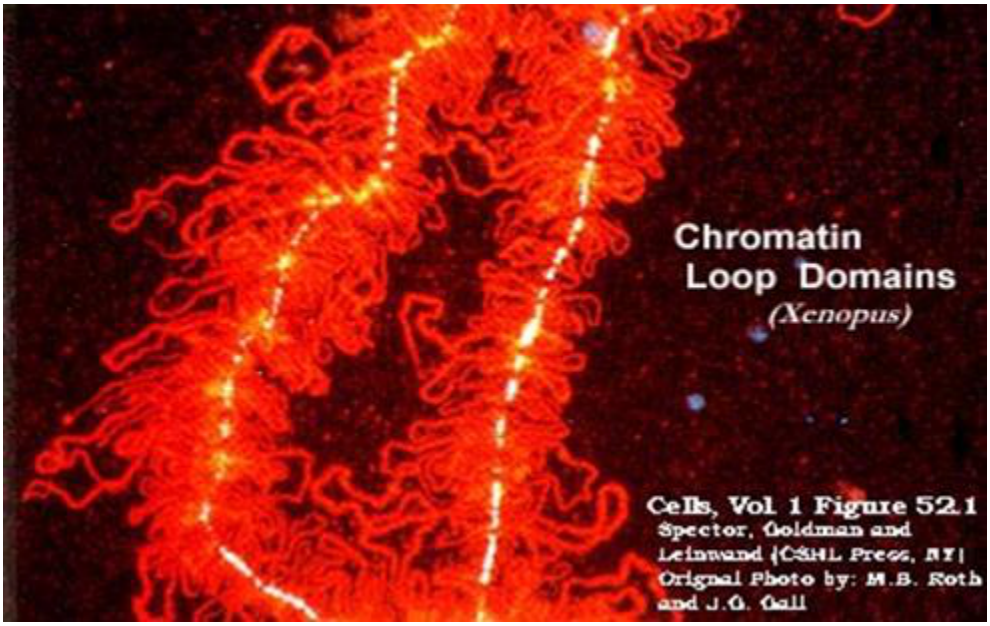
5. (10 points) In the figure below, an oval indicates the presence of a circular genome in various genera of prokaryotes, whilc a rod indicates a linear genome. What does this figure tell you about the evolution of linear genomes in prokaryotes.




6. (5 points) To make it possible for sperm to swim rapidly through a viscous environment, it is necessary for each sperm cell to have as narrow a cross-section as possible. What evolutionary adaptation has occurred in the nuclei of mamalian cells that helps to minimize the size of the sperm head?

7. (15 points) Suppose you wanted to genetically engineer plants to express a disease resistance gene constitutively, using the 35S promoter. In doing so, you want to eliminate the problem that when genes insert at random chromosomal sites, some sites are favorable to expression of the foreign gene, and others tend to express the gene weakly, or not at all. What is a common mechanism for these site-specific differences in expression? Draw a simple map of a recombinant construct designed to overcome this problem. Explain how the construct solves the problem.

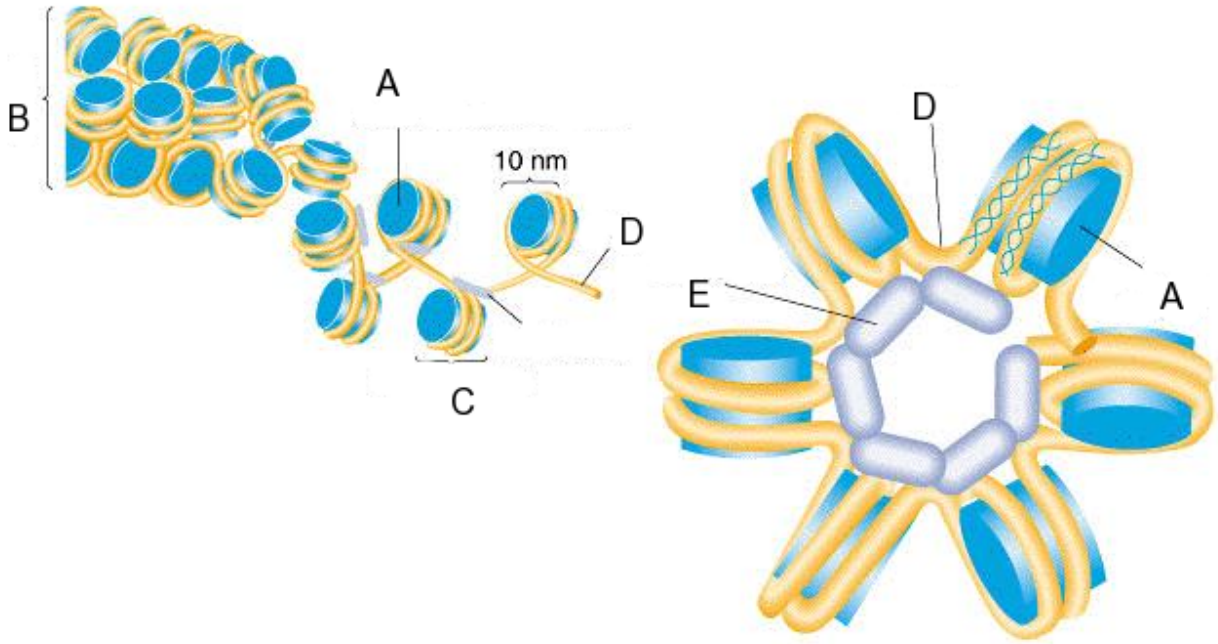
8. (10 points) In the figure at right a "lampbrush" chromosome from Xenopus oocytes during meiotic metaphase I. These lampbrush chromosomes show a strong signal when probed with flourescent antibodies to Topoisomerase II. What does this observation tell us about the chromosome scaffold, and the mechanism by which chromatin structure controls gene expression? Why are lampbrush chromosomes so unusual for cells at meiotic metaphase I?




9. (10 points) (Note: the term b is used twice in this paragraph.)

At _____a_____ of mitosis, the chromosomes are tightly clustered together in bundles resulting from migration of the chromosomes to opposite poles of the mitotic call during anaphase. Thus, the _____b_____ of the chromosomes in the newly-forming nucleus reflects the _____b_____ of the chromosomes in telophase. At this stage, the _____c_____ re-forms around the individual chromosomes, and the resultant vesicles fuse to form a _____d_____. The 3-dimensional locations of the chromosomes during interphase are referrred to as _____e_____.

10. (10 points) Name the chromatin components labeled in the image below. Where a label is used twice, you can assume it is the same structure.




A.

B.

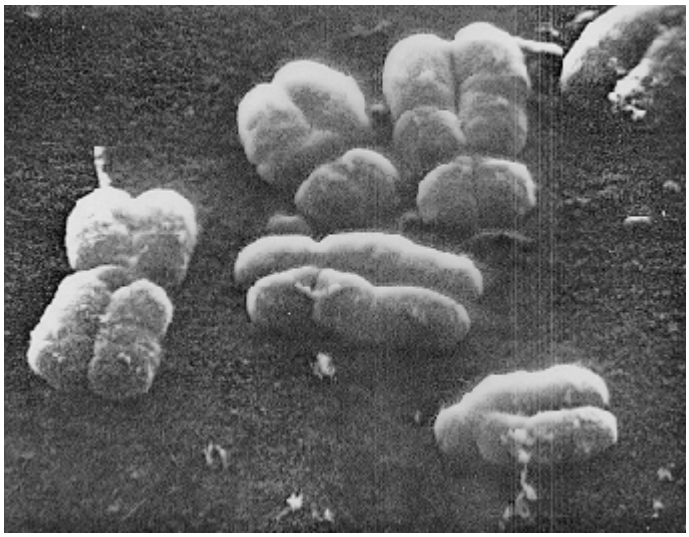
C.

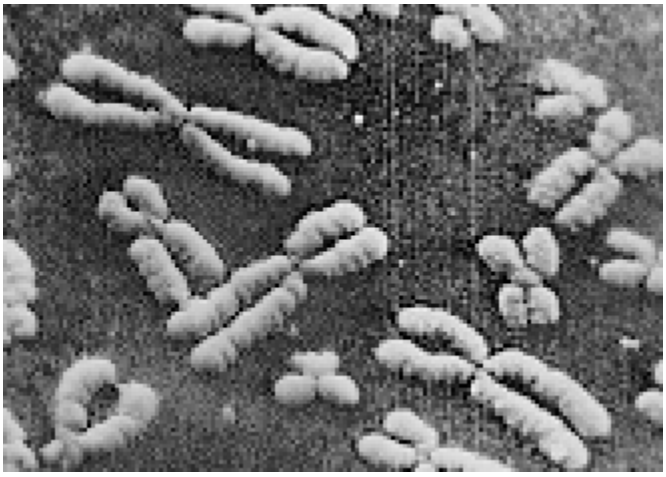
D.

E.

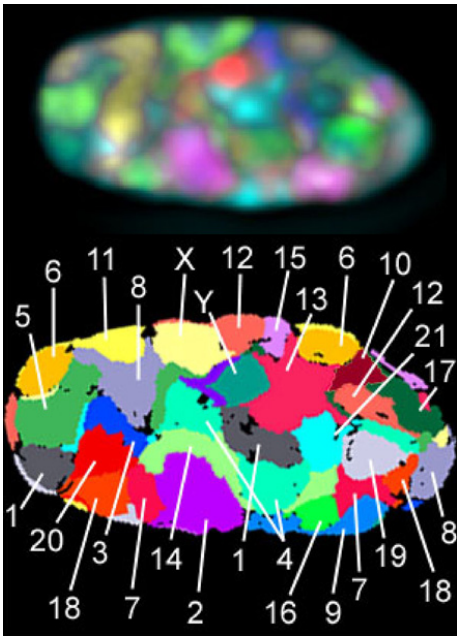
11. (5 points) Which of these electron micrographs shows G-banded chromosomes, and which shows untreated chromosomes? Explain your answer.

**A** **B**





12. (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?