

CELL REPRODUCTION and MENDELIAN GENETICS

NOTE to STUDENTS and FACILITATORS: One of the main purposes of the Workshops is to allow free exchange of information by **having each member of a Learning Community in turn answer one part** of a discussion question. As each student explains a term or gives a definition in their own words, it should allow for free verbal EXCHANGE and promote learning by interaction. **Try to insure that everyone in your Learning Community does a question or two and the purpose of the exercise is that they must EXPLAIN THEIR ANSWERS to the rest of the community.**

CELL REPRODUCTION:

The goal of today's exercise is for you to investigate **mitosis** and **meiosis** and to acquire the ability to solve some standard varieties of genetics problems. You will need to have a working familiarity with concepts such as phenotype, genotype, heterozygous, homozygous, dominant, and recessive.

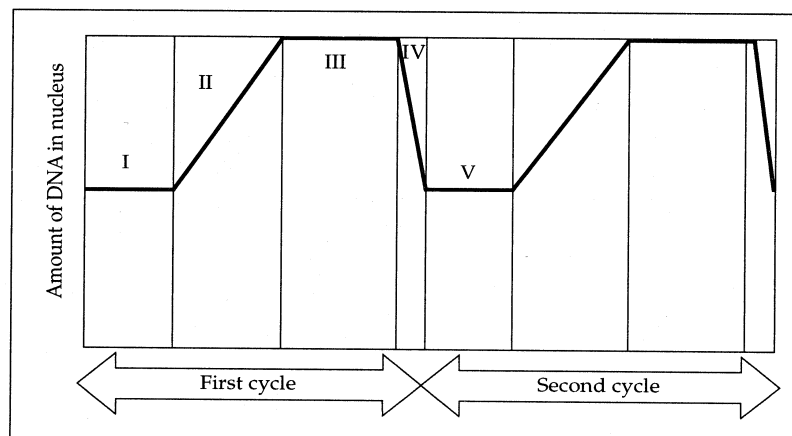
Part 1. Mitosis & Meiosis

1. If there are 12 chromosomes in a plant cell at the G1 stage of the cell cycle, then ?
 - a) what is the diploid chromosome number of this plant? and explain your answer?
 - b) how many chromatids would be present at anaphase?
 - c) the progeny cells, after cytokinesis, would contain how many chromosomes?

2. Measurements of the amount of DNA per nucleus were taken on a large number of cells from a growing cell culture of mouse fibroblasts. The measured DNA levels ranged from 3 to 6 picograms per nucleus. One nucleus had 5 picograms of DNA. What stage of the cell cycle was this nucleus in? and how did you know?

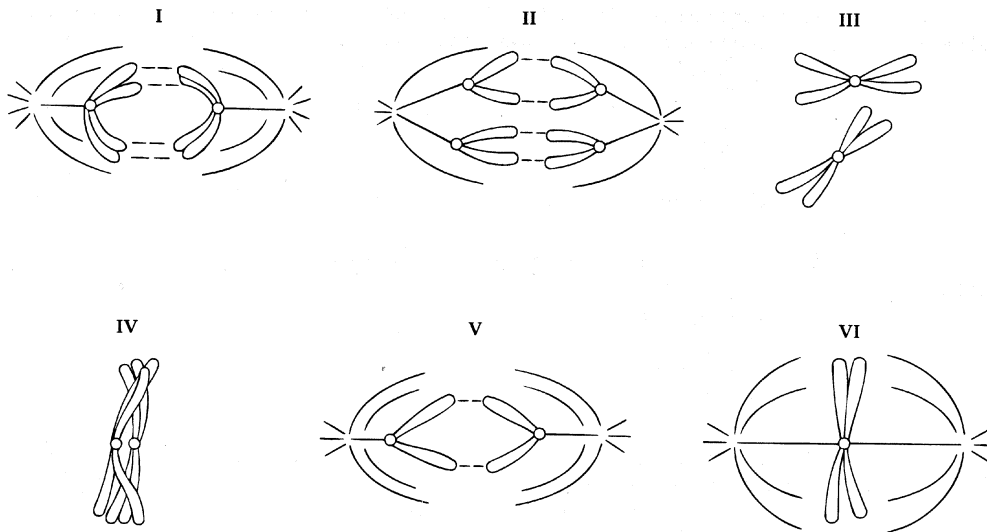
3. A common chemo-therapeutic drug used to treat cancerous cell growth is Taxol, a compound extracted from the Pacific Yew tree. In animal cells this anticancer drug disrupts microtubule formation by binding to MT's and accelerating their assembly from the precursor, tubulin. How might showing such a drug affect cancer cells?

4. Referring to the figure below showing DNA amounts in a cell during the course an asexual cell division:
 - a) Label the stages of mitosis that are comparable to the numbers : I, II, III, IV
 - a) At which stage (I, II, III, IV, or V) is the centromere uncoupling and the chromatids separating?
 - b) MPF, Mitotic Promoting Factor, reaches its highest concentration threshold in the dividing cell during which stage ?
 - c) The DNA content of the cell is tetraploid at this stage? What is tetraploid?
 - d) This graph depicts mitosis or meiosis? and how do you know this?

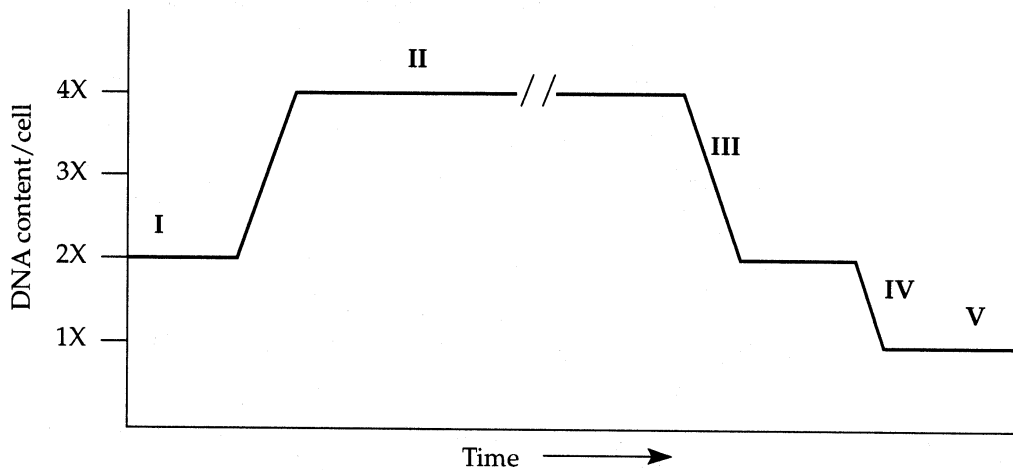


5. If a liver cell of an animal contains 24 chromosomes, then the sperm cells of this animal would have how many chromosomes? Why?

6. How does the process of sex and sexual cell division increase the genetic variability in a species?



7. Refer to the figures of meiosis above to answer each of the following questions:
- Which drawing best depicts prophase I of meiosis ?
 - At the completion of which drawing above will the chromosomes have the least amount of DNA ?
 - Anaphase I is best shown in which drawing ?
 - Metaphase II is best shown in which drawing ?
8. Refer to the diagram below, which plots DNA per cell during sexual cell division and meiosis.
- label the stages (I, II, III, IV, V) with comparable stages to sexual cell division?
 - In which number (I, II, III, IV, or V) would you expect crossing over to occur?
 - Which number would represent when the DNA content is that found in egg cells?
 - At which number would the separation of homologous chromosomes occur?
 - Where would you place crossing over on this diagram?



9. As a group with each member contribution and answer describe the major significant differences between asexual cell division and sexual cell division.

MENDELIAN GENETICS PROBLEMS...

Part 2. Some genetic crosses for practice: (the member answering each question can use a blackboard if available).

1. In the following cross **AaBB x aaBb** where A, red eye color is dominant over a, green eye color and B, bald is dominant over b, lots of hair...
 - a. What are the resulting genotypes and what are their ratios (assuming no linkage between the two gene loci)?
 - b. What are the resulting phenotypes and what are their ratios?
 - c. What fraction of the offspring are heterozygous for eye color?
 - d. What fraction of offspring are homozygous for baldness?

HINT: To answer the above questions, try the following: first determine what gametes were possible from each parent, then determine the resulting possible offspring by making all possible combinations between the two parents.

2. Consider the following dihybrid cross **aaBb x AaBb**
 - a. How many different genotypes can be present in the first-generation offspring from such a cross?
 - b. How many phenotypes?

HINT: You should be able to solve problems of the type given above for any cross. This is a general tool that needs to be developed by you. Just memorizing the standard 9:3:3:1 ratios from a dihybrid cross will give you one answer to one cross. By developing the general skill you are able to do any cross.

3. Consider the following cross: **AabbCcDd x aaBbccDd**
 - a. What are the odds of the F1 generation being homozygous recessive at gene locus B?
 - b. What are the odds of the F1 generation being homozygous dominant at gene locus D?
 - c. What are the odds of the F1 generation being both homozygous recessive at gene locus B and homozygous dominant at gene locus D? [Hint: just combine the two results above. Can you determine how the combination is to be done?]
 - d. Using the way you answered the above three questions, can you think of a general way to approach such multiple-gene-locus probabilities?

Part 3. Sex-linked traits

Sex-linked traits work somewhat differently than autosomal traits. Alleles that are found on the X chromosome in humans have a distinct inheritance in males, since they get just one copy of the X, which comes from the maternal parent.

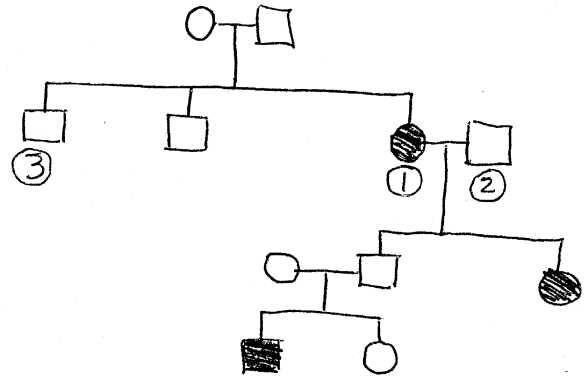
1. If a woman who is homozygous for normal color vision marries a man who is color blind (a sex-linked, recessive trait), what proportion of their offspring (separately indicate results for males and females among their offspring) would...
 - a. be carriers of the color blindness trait?
 - b. be color-blind?
2. If a woman is heterozygous for color blindness (sex-linked, recessive) and marries a male with normal color vision, among their offspring (separately consider males and females), what proportion would
 - a. be carriers?
 - b. be color-blind?

Part 4. Pedigree Analysis

1. Consider the following pedigree:

- squares = males; circles = females.
- a filled square or circle indicates that the individual has a disorder that causes premature aging.

To answer the questions use: A = dominant allele,
a = recessive allele.



- Is the trait dominant or recessive?
How do you know?
- Is there any indication that the trait is sex-linked?
Give your reasoning.
- What are the likely genotypes of each of the three individuals (1, 2, 3) indicated above?

Part 5. Multiple Alleles. (Refer to textbook – pg 280)

In the above problems we have considered a maximum of two alleles at each gene locus. Of course, in an individual this is the maximum number possible, but that is not true in a population. There can be many alleles at a given gene locus in a population.

- Consider a gene locus with three different alleles in a population.
 - How many different possible allele combinations are there in individuals in this population?
 - It so happens that there are three alleles that determine blood groups (A, B, and 0 are the three alleles). Antibodies can be made against A and B gene products, but not 0 gene products, and these antibodies are only made if an individual does not have that allele. Given the above, list the different possible blood types, and determine what transfusions are and are not possible between these different blood types?

Part 6. Genetic Counseling: some thought questions...

Imagine that you are a physician. How would you deal with each of the following cases?

- A woman comes in whose only child has Down syndrome. She informs you that she is pregnant and asks what the odds are of her having another child with Down's. Can you give her odds of whether she will have another such child? What one piece of information about her would be most helpful?
- Hemophilia is a sex-linked, recessive trait. A woman whose father had the trait wants to know what the odds are that her sons will have the disorder. What do you tell her?