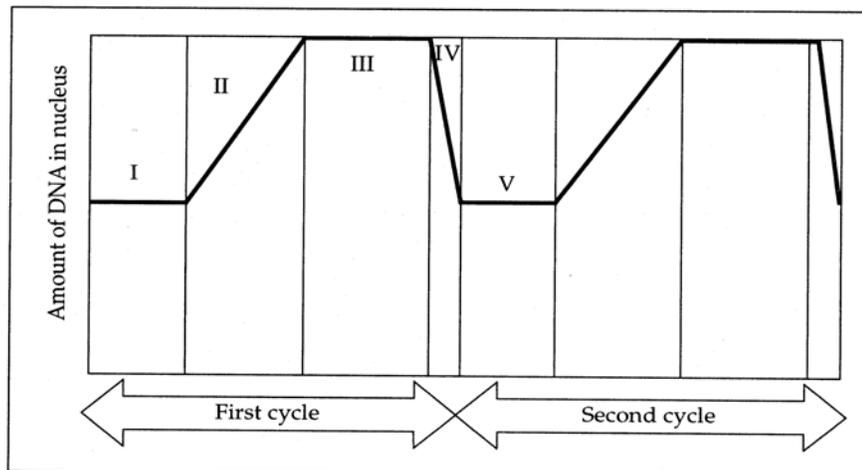


CELL REPRODUCTION and MENDELIAN GENETICS**CELL REPRODUCTION**

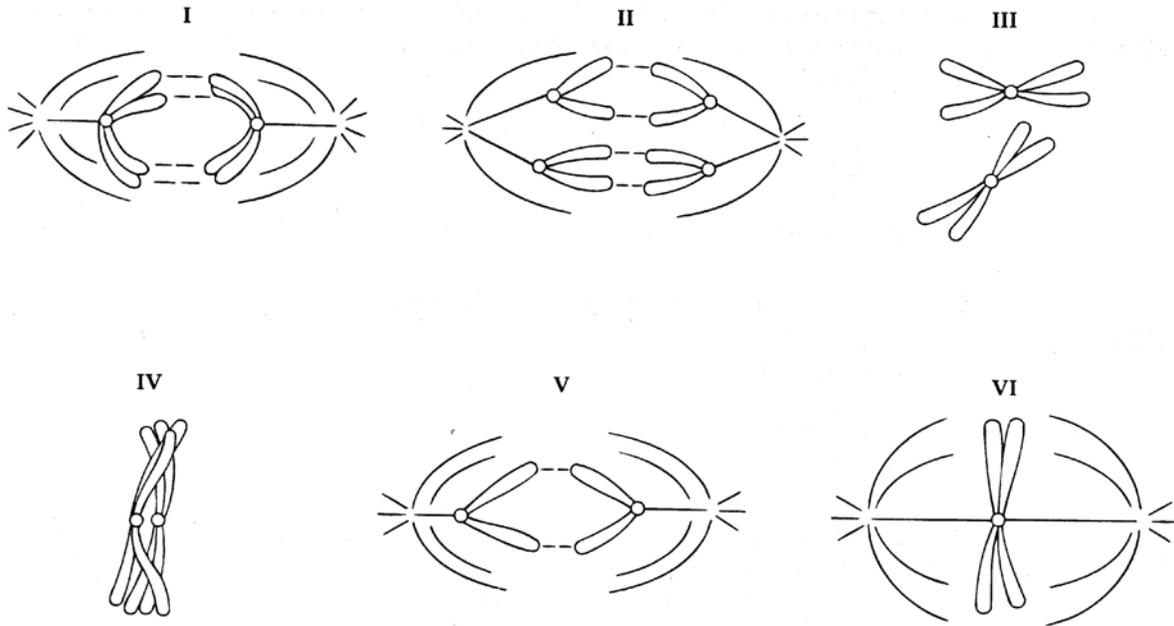
The goal of today's exercise is for you to look at **mitosis** and **meiosis** and to develop the ability to solve some standard types of genetics problems. You will need to have a working familiarity with concepts such as phenotype, genotype, heterozygous, homozygous, dominant, and recessive. Have one member, in turn, of your Learning Community answer one part of each of the questions or problems, then let the next member go on to the next part....

Part 1. Mitosis & Meiosis

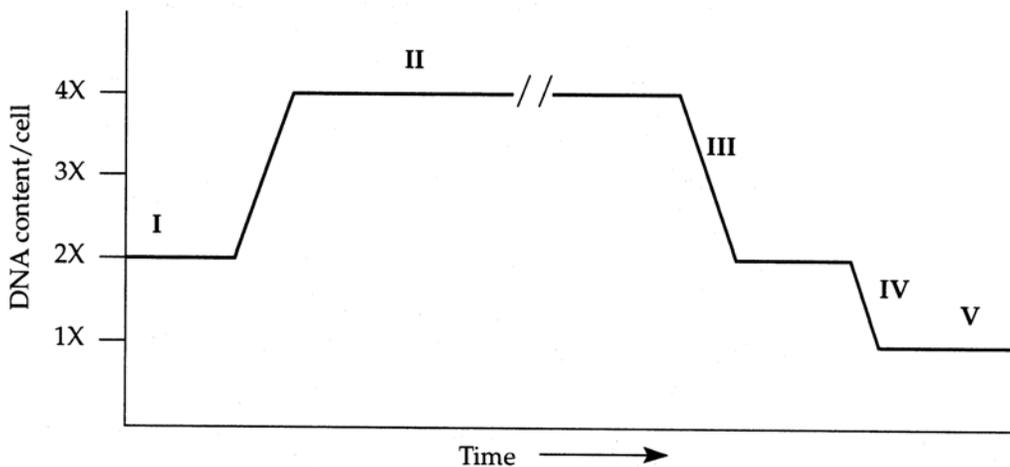
- If there are 12 chromosomes in a plant cell at the G1 stage of the cell cycle, then ?
 - what is the diploid chromosome number of this plant? and Why?
 - how many chromatids would be present at anaphase?
 - the progeny cells, after cytokinesis, would contain how many chromosomes?
- Measurements of 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?
- 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 does such a drug affect cancer cells?
- Referring to the figure below of DNA amounts in a cell during the course a asexual cell division:
 - Label the stages of mitosis that are comparable to the numbers : I, II, III, IV
 - At which stage (I, II, III, IV, or V) is the centromere uncoupling and the chromatids separating?
 - MPF, Mitotic Promoting Factor, reaches its highest threshold concentration in the dividing cell during this stage ?
 - The DNA content of the cell is tetraploid at this stage ?
 - This graph depicts mitosis or meiosis? and how do you know this?



- If a liver cell of an animal contains 24 chromosomes, then the sperm cells of this animal would have how many chromosomes? Why?
- 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 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. Have one member of your Learning Community describe to all the other the major significant differences between asexual cell division and sexual cell division.

MENDELIAN GENETICS PROBLEMS...

Part 2. Some practice genetic crosses:

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 from above. Alleles that are found on the X chromosome in humans have a special inheritance in males, since they get just one copy of the X and it comes from the mother. This is one of the distinctions between autosomal and sex chromosomes.

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?

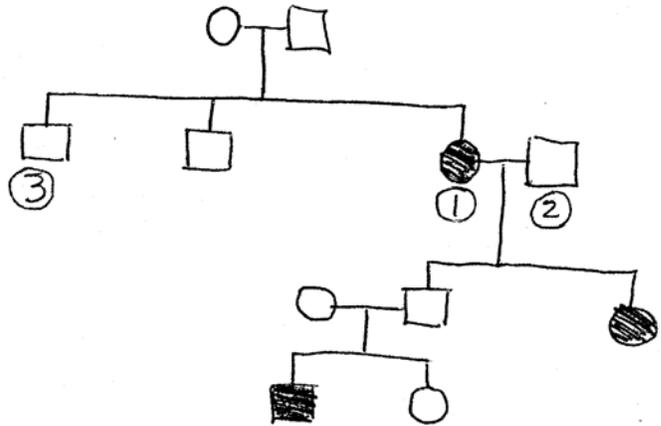
Part 4. Pedigree Analysis

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.



a. Is the trait dominant or recessive?

How do you know?

b. Is there any indication that the trait is sex-linked? Give your reasoning.

c. What is the genotype of each of the three individuals (1, 2, 3) indicated above?

Part 5. Multiple Alleles. (Refer to textbook – pg 257-259)

In the above cases 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.

1. Consider a gene locus with three different alleles in a population.

a. How many different possible allele combinations are there in the individuals in the population?

b. 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?

2. The Major Histocompatibility Complex (MHC) in humans consists of a group of cell surface glycoproteins. These are involved in immune system's response and the rejection of organ transplants. About twenty gene loci are involved and at each locus there are about 50 different alleles in the population today. How many different allele combinations are possible? Compare this to the number of humans alive today, about 5.6 billion.

Part 6. Epistasis. (Refer to textbook – pg 258)

The product of one gene can influence the phenotypic expression of another gene. Consider the Black/Brown gene locus in mice and the influence of the alleles at a second gene locus, designated C. BB and Bb animals are black, and bb animals are brown UNLESS the animals also are homozygous recessive at the C locus, in which case they have white fur color. Review this case of epistasis in your book, p. 250, and then answer the following:

1. consider the cross: **BBCC x BbCc**

a. What color are each of these parents?

b. What percent of the F1 offspring will be black, what % brown, and what % white?

2. Consider the cross: **BBCC x Bbcc**

a. What color are each of these parents.

b. What percent of the F1 offspring will be black, what % brown, and what % white?

Part 7. Linked genes and mapping. (Refer to textbook – pg 275-276)

Genes can be close enough to one another on a chromosome that they are more likely to be inherited together. These are linked genes. Only recombination through crossing-over allows them to be separated during meiosis. The fraction of recombinant offspring can be used as a measure of how close the two gene loci are on the chromosome. A series of such fractions among mutually linked genes also can be used to map genes on chromosomes.

1. Imagine that you have performed a cross and seen that there are 499 parental types and 502 recombinants, for a total of 1,001 offspring.
 - a. What is the recombination frequency?
 - b. Are these two genes linked?
2. In a cross there are 500 parental types and 100 recombinants.
 - a. What is the recombination frequency?
 - b. Are these two genes linked?
3. a. Use the following recombination frequencies to map four genes, A-D.

<u>Gene pair</u>	<u>Recombination frequency</u>
A, B	8%
A, C	4%
A, D	4%
B, C	4%
B, D	12%

After drawing the appropriate map, what is the map distance between genes D & C ?

- b. Consider that there is a fifth gene E that also is linked. If you know that the A-to-E recombination frequency is 4%, can you locate E on the map you constructed above?

Part 8. Genetic Counseling. (Refer to textbook – pg 260-266)

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

1. 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?
2. A man comes in to ask about his chances of getting Huntington's disease, a relatively rare, dominant disorder. His mother has just come down with the disorder. What could you immediately tell him about the odds? Is there a test that could be done to tighten the odds?
3. 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?

Part 9. I.Q. tests, and polygenic inheritance.

Many phenotypic traits, such as height, intelligence, and cardiovascular health in humans, depend upon a number of different genes (polygenic inheritance), and also depend upon environment. The following is a discussion question.

1. If one does a test of the proportion of variance due to genotypes and environment in a limited population of humans, say white males in the United States, one finds that more than half of the variation at any time can be accounted for by variation in genotypes: different alleles and combinations of alleles in different individuals. At the same time, if one looks across time during the last seventy years, I.Q. scores have increased dramatically in the United States. Do you think that intelligence has increased dramatically, too? Are genotypes changing rapidly enough to account for such dramatic changes? Can the fraction of variance caused by genotype be high in a population and still have that population dramatically affected by changes in environment? What implications does this have for explanations of differences in I.Q. scores between different populations of humans?