CELL REPRODUCTION and MENDELIAN GENETICS **ANSWERS**

The goal of today's exercise is for you to understand mitosis & meiosis and develop the ability to solve some standard types of genetics problems.

CELL REPRODUCTION:

Part 1. Mitosis & Meiosis
1. a) The diploid chromosome number of this plant is most likely 12. G1 is the stage prior to DNA duplication and normally contains the diploid amount of DNA for a species.
   b) Since each chromosome duplicates itself and becomes visible during mitosis, there should be 24 chromatids present at anaphase. When the centromere duplicates during mitosis at that point we would refer to the chromatid as another chromosome.
   c) The daughter cells, after cytokinesis, would contain the diploid number of chromosomes for this species which is 12.

2. The nucleus, which had 5 picograms of DNA, is probably in late S, just before G2. The measurements of the amount of DNA ranged from 3 to 6 picogram. Assuming that these cells are dividing mitotically and allowing for statistical error this suggests that the diploid amount of DNA for these cells is near 3 picograms and the tetraploid (doubled) amount of DNA would be 6 picograms. Thus 5 picograms places the cell in late S, just before G2.

3. Taxol is one of several cytoskeletal drugs (another is Colchicine) which function by interfering with the dividing cell's ability to process microtubules and the mitotic spindle. Taxol stabilizes microtubule polymers preventing disassembly thus chromosome are unable to form a metaphase spindle configuration blocking the progression of mitosis. Unable to complete the division cycle the cell dies.

4. Referring to the figure:
   a) I = G1,   I = S phase,   III = G2,   and   IV = cytokinesis.
   b) Stage IV, or during the anaphase of mitosis is when the centromere uncouples and the chromatids separate?
   c) MPF, Mitotic Promoting Factor, reaches its highest threshold concentration in the dividing cell just before mitosis, which is G2 or stage III in this graph.
   d) The DNA content of the cell is tetraploid after the DNA has duplicated in the S phase, which is stage III.
   e) This graph depicts mitosis because the amount or DNA per cell never goes below the baseline level depicted in stages I and V, which is the diploid amount. (see the next figure which depicts DNA content in meiosis).

5. The sperm cells would have half the chromosome number of the diploid content of this animal species. If the diploid number of chromosomes is 24 then the haploid number ought to be 12.

6. The process of sex and sexual cell division increases the genetic variability in a species by 1) allowing the recombination of chromosomes from two different individuals, 2) by allowing recombination of alleles on a chromosome   and 3) by producing gametes with different combinations of parental chromosomes ?

7. Refer to the figures of meiosis above to answer the following questions:
   a) Drawing IV best depicts prophase I of meiosis, since it shows a pair of homologous chromosomes paired at synapsis and indicates that crossing over may be occurring, which is what happens in prophase I.
   b) The cell would have the least amount of DNA after meiosis II is complete, when the cells are haploid. Drawing V depicts the separation of 2 chromatids. If we assume from these drawings a chromosome number of 2, which is what most show, then the reduction division of meiosis II would produce daughter cells with the haploid chromosome number of 1, which would be the consequence of drawing V.
   c) Anaphase I, which separates pairs of a homologous set of chromosomes from each other, is shown in drawing I.
   d) Metaphase II, when the sister chromatids of one homolog of a pair align at the equatorial plate, is best shown in drawing VI.

8. Refer to the diagram of DNA during MEIOSIS to answer this question.
    a) I = G1 of meiosis 1, II = G2 of meiosis 1,   III = meiosis 1 itself, IV = meiosis II itself,
        and V = interphase of haploid cell (sperm or egg).
    b) In Number III is where crossing over mos likely would occur.
    c) Number V represents the stage when the DNA content is that of a haploid egg cell.
    d) Number III is the time when the separation of homologous chromosomes occurs.
    e) Number III is where you would place crossing over on this diagram.

9. The major significant differences between asexual cell division and sexual cell division include:
    a) the number of cells divisions that occur - one for mitosis and two for meiosis.
    b) the fact that reduction division takes place in meiosis but not mitosis, where the chromosome number if halved
    c) the process of crossing over, which allows for the creation of new chromosome variations that did not exist in
         the parental cell, and which forms the basis of genetic variability in a population of organisms.
    d) the process of random assortment, which allows the homologs of a homologous pair to align at the equatorial
         plate prior to separation in a random pattern, meaning that an infinite number of combinations of homologous
         pairings is possible. Therefore, the progeny cells have a multitude of various combination of genes and that
         contributes greatly to genetic variation in a species.

MENDELIAN GENETICS   Part 2. Some genetic crosses:

1. **AaBB x aaBb**
    there are 4 possible genotypes…   Each with the ratio of 1:1:1:1

    a. genotypes

	aB	ab
AB	AaBB	AaBb
aB	aaBB	aaBb

    b. phenotypes: ½ red eyes, bald   and   ½ green eyes, bald
    c. ½ heterozygous for eye color
    d. ½ homozygous for baldness

2.
    aaBb x AaBb

        a. genotypes: Thus, there are 6 genotypes as shown in the table below:

	AB	Ab	aB	ab
aB	AaBB	AaBb	aaBB	aaBb
ab	AaBb	Aabb	aaBb	aabb

    b. 4 phenotypes:
        3/8 dominant for A and B   3/8 recessive a dominant B
        1/8 dominant A, recessive b   1/8 recessive a, recessive b

3.   a. The odds that the F1 will be homozygous recessive for gene "b" is :
        2/2 x 1/2   =   ½ or 50% ; i.e.,   2 out of 2 chance to get a "b" from one parent
                                        and a 1 out 2 chance to get a "b" from the other parent = 50%

    b. ½ x ½ = ¼ or 25%   [Dd x Dd]

    c. 1/4 x 1/2 = 1/8 or 12.5%

Part 3. (Sex linked traits).
      1. XX x XcY
          a.   100% of females and 0% of males are carriers
          b.   0% of females and 0% of males are colorblind

	Xc	Y
X	XXc	XY

      2. Xc X x XY
          a.   50% of females are carriers
          b.   50% of males and 0% of females are colorblind

	X	Y
Xc	XXc	XcY
X	XX	XY

Part 4. Pedigree Analysis
      a. Recessives skip generations and can show up in offspring when not in the parents…
            (this could also happen as a dominant via a new mutation, but that would be rare).
      b. No. because a daughter (1) gets disorder when neither parent shows the disorder.
      c. likely genotypes are: ① = aa;   ② = Aa; &   ③ = Aa or AA.

Part 5. Multiple Alleles
      1. a. Three different alleles: A, a, and a*
              possible allele combinations - AA, Aa, Aa*, aa, aa*, a*a*
         b. Possible blood types:
              AB:,   can accept blood from type A, B, AB, and O
              A   can accept blood from type A and O
              B   can accept blood from type B and O
              O   can accept blood from type O only.

Part 6. Genetic Counseling
    1. How old she is ? The older the pregnant female, the greater the likelihood of a chromosomal
         aberration event as non-disjunction.

    2. She is a carrier, since her father had the disorder. 50:50 for sons

(see Part III.2.)