

CELL REPRODUCTION and MENDELIAN GENETICS **ANSWERS**

The goal of today's exercise is for you 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 of problems, then let the next member go on to the next part, etc..

CELL REPRODUCTION

Part 1. **Mitosis & Meiosis**

- 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, and other anticancer drugs as Colchicine, function by interfering with the dividing cell's ability to form the fibers of the mitotic spindle. At the time when the chromosomes are supposed to have the spindle fibers attach to pull the chromosomes to opposite poles nothing happens. The result is that the cell most likely will be unable to complete the division cycle and die.
4. Referring to the figure below:
 - a) I = G1, II = S phase, III = G2, and IV = cytokinesis.
 - b) Stage IV, or during the anaphase portion 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 of 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 combination 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 the pairs of a homologous set of chromosomes from each other, is best 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.
- 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).
 - In Number III is where crossing over most likely would occur.
 - Number V represents the stage when the DNA content is that of a haploid egg cell.
 - Number III is the time when the separation of homologous chromosomes occurs.
 - 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:
- the number of cell divisions that occur - one for mitosis and two for meiosis.
 - the fact that reduction division takes place in meiosis but not mitosis, where the chromosome number is halved
 - 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.
 - 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 combinations of genes and that contributes greatly to genetic variation in a species.

MENDELIAN GENETICS [Part 2. Some genetic crosses:](#)

1. **AaBB x aaBb**

a. genotypes

Thus, there are 4 possible genotypes, each 1:1:1:1

	aB	ab
AB	AaBB	AaBb
aB	aaBB	aaBb

b. phenotypes: $\frac{1}{2}$ red eyes, bald and $\frac{1}{2}$ green eyes, bald

c. $\frac{1}{2}$ heterozygous for eye color

d. $\frac{1}{2}$ 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
- 1/8 dominant A, recessive B
- 3/8 recessive A, dominant B
- 1/8 recessive A, recessive B

3. a. The odds that the F1 will be homozygous recessive for gene "b" is :

$$2/2 \times 1/2 = 1/2 \text{ or } 50\% ;$$

i.e., 2 out of 2 chance to get a "b" from one parent

and a 1 out of 2 chance to get a "b" from the other parent = 50%

b. $1/2 \times 1/2 = 1/4$ or 25% [Dd x Dd]

c. $3/4 \times 1/4 = 3/16$ or 18.75%

Part 3. (sex linked traits).

1. XX x X*Y

- a. 100% of females and 0% of males are carriers
- b. 0% of females and 0% of males are colorblind

	X*	Y
X	XX*	XY

2. X* X x XY

- a. 50% of females are carriers
- b. 50% of males and 0% of females are colorblind

	X	Y
X*	XX*	X*Y
X	XX	XY

Part 4. Pedigree Analysis

- a. Recessive--skips generations--shows up in offspring when not in parents (this could happen with dominant, by new mutation, but would be rare)
- b. No. Daughter 1 gets disorder when neither parent has disorder.
- c. ① = aa; ② = Aa; and 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.

2. $20^{50} =$ about 1.1×10^{56} , much greater than 5.6×10^9 .

Part 6. Epistasis

1. **BBCc x BbCc**

a. both parents are black, thus, 75% are black, 0% are brown, and 25% are white.

	BC	Bc	bC	bc
BC	BBCC	BBCc	BbCC	BbCc
Bc	BBCc	BBcc	BbCc	Bbcc

2. **BBCc x Bbcc**

a. one parent is black, the other white, thus, 50% are black, 0% are brown, and 50% are white

	Bc	bc
BC	BBCc	BbCc
Bc	BBcc	Bbcc

Part 7. linked genes and Mapping

1. a. recombination freq. - $502/1.001 = 0.501$ (within an error of 0.5)
- b. no evidence of linkage

2. a. recombination freq. = $100/(500+100) = 0.1667$
- b. yes, linked



- b. Not exactly. E could be on either side of A.

Part 8. 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. 50:50. Yes, a genetic test (marker) is available
3. She is a carrier, since her father had the disorder. 50:50 for sons
(see Part III.2.)

Part 9. IQ Tests and Polygenic Inheritance

If you wish a simpler example than intelligence, consider height. Height also is predominantly influenced by genotypes among individuals in a given population, say, China. Nevertheless, by changing environment, one can significantly influence height. For example, Chinese offspring who grow with a Western-style diet will show dramatic height increases compared to their parents. A measure of inheritability of a trait is limited only to the environment, or range of environments, the population experienced. Environments differ in different locations and differ even at the same location at different times.