BB2920 Problem Set 3 Solutions

**Problem 1 (30 points)**

*C. elegans*, a microscopic roundworm, is often used as a model organism by geneticists. Imagine you are studying a mutation in the (fictional) nco-1 gene (named “no crossing over”) in *C. elegans*, that prevents crossing over between homologous chromosomes, but otherwise the chromosomes pair normally. Assume that, other than the inability to cross over, meiosis proceeds normally.

a) The diploid chromosome number in C. elegans is 10. How many possible gametes could be formed by an individual with the nco-1 mutation? (looking for an exact number here)

**2^n = 2^5 = 32 possible gametes [5 points, deduct 3 points if they come up with 2^10=1024, this is actually 2^2n, not 2^n.]**

b) Imagine that a similar gene to your nco-1 gene exists in humans, and that the gametes of individuals with a human nco-1 mutation are viable (the individuals are fertile). How many possible gametes could a person with this mutation produce? (looking for an exact number here)

**there are 2^23 = 8388608 possible gametes [5 points, deduct 1 if they come up with 2^23 but calculate 8388608 wrong or don’t calculate it at all]**

(c) What is the likelihood that a man and a woman that both have the nco-1 mutation could produce two genetically identical offspring from different pregnancies? (calculate a number and describe your reasoning).

**The likelihood of any particular gamete being selected is 1/8388608 (2^23). In order to replicate the first pregnancy, the likelihood is 1/8388608 (same egg) x 1/8388608 (same sperm) = 1/(7.04 x 10^13)**

**[10 points, award half credit at your discretion if they are close but calculate wrong. Keep in mind that the first child can have ANY chromosomal arrangement, it doesn’t matter. So assuming that the child exists and has normal ploidy, the probability of their having a set of chromosomes is 1. The question is: what is the probability of re-creating an individual with the exact same chromosomes as the first offspring?]**

(d) A different mutation, in the gene hec-1 (a critical component of the kinetochore complex) affects the kinetochore such that microtubules can no longer connect to opposing sides of both sister chromatid kinetochores, but can only attach to one side or the other.

Would this mutation cause a problem in meiosis I? What about meiosis II? Explain what would happen to the developing gametes in each case.

**Meiosis I: no, because both sister chromatids are pulled into the same cell anyhow during meiosis I, so its likely not going to be a problem. [5 points, half credit for answers that are on the right track but not entirely right, or if the student does not provide an explanation]**

**Meiosis II: yes, this is a problem because the sister chromatids need to separate to make haploid cells. If they cannot separate the sisters will be pulled into the same daughter cell, and the resulting gametes would have double copies of some chromosomes and no copies of others. [5 points, half credit for answers that are on the right track but not entirely right, or if the student does not provide an explanation]**

**Problem 2 (30 points)**

Zebras are part of the equine family, but zebras, horses, donkeys and other equines all have vastly different chromosome numbers.

In horses, 2n=64. In some zebras, 2n=44. Crosses between a zebra and another equine species are known as zebroids. Typically a zebroid looks like a striped version of the horse parent.

a) Assume the horse and zebra with chromosome numbers listed above are crossed. How many chromosomes are in a somatic cell in the resulting zebroid? How did you arrive at this number? Explain using your knowledge of meiosis, NOT the internet!

**This zebroid would have 54 chromosomes in their somatic cells, a combination of a of a horse gamete which has 32 chromosomes, and a zebra gamete which has 22 chromosomes. [10 points total, 5 points for coming up with the answer of 54 chromosomes, 5 points for the explanation that its because of the merging of those two gametes]**

b) Would you expect there to be a problem with a zebroid’s cells during mitosis? Why or why not?

**there is no problem having an odd number of chromosomes during mitosis, because homologous chromosomes do not pair during mitosis. As long as the chromosome can replicate and form a sister chromatid, the cells are fine. [10 points, award half credit at your discretion for partially correct reasoning]**

c) most zebroids are sterile because their gametes are not viable. Why? What specifically is the problem?

**Chromosomes must be paired with their homologs prior to meiosis I. because the 54 chromosomes that the zebroid has are not truly homologous (32 from one parent and 22 from the other) these will not be able to pair correctly during prophase 1. This will lead to unpaired chromosomes that will result in uneven distribution to the gametes, resulting in non-viable gametes. [10 points, award half credit at your discretion. they must recognize that there is a lack of homologous pairing to receive full credit]**

**Problem 3 (20 points)**

You have a fruit fly with shiny wings, which you believe is a dominant phenotype, because you have noticed more shiny winged flies (W) than dull winged flies (w). How would you determine if a given shiny winged fly is homozygous or heterozygous for the W allele?

a) Describe the genetic cross you would perform, and the possible outcomes of progeny for each case (homozygous and heterozygous). **You would do a test cross to a dull winged fly, as this is likely a homozygous recessive. If the fly is WW, then you will get all shiny winged offspring from the testcross. If the fly is Ww, you will get half shiny winged and half dull winged.** **[10 points, assign half credit at your discretion for incomplete answers]**

b) draw out the Punnett squares to illustrate your answer to part a. **[10 points, 5 points per punnett square, no partial credit as this is a very easy question]**

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Problem 4 (20 points)

You have two laboratory mice, a male and a female, that are both black. You are told by a labmate that these are pure-breeding strains, which means they are homozygous all possible alleles. You breed the animals continuously for a year, and while most of the offspring are black, you do see a few with grey fur. Of the 64 total offspring generated over the year, 15 were grey. What’s going on? Did your lab mate make a mistake? Explain, and draw a Punnett square to illustrate your explanation.

**Both animals must be heterozygous (Bb) for the gene that controls fur color. The 3:1 ratio of offspring is consistent with a Bb x Bb cross. So your lab mate gave you the wrong animals. [10 points for the written explanation, 10 points for the correct punnett square]**

**B b**

**B BB Bb**

**b Bb bb**