Human Genetics:
Problem Set I

Youngduck Choi
CILVR Lab
New York University
yc1104@nyu.edu

Abstract

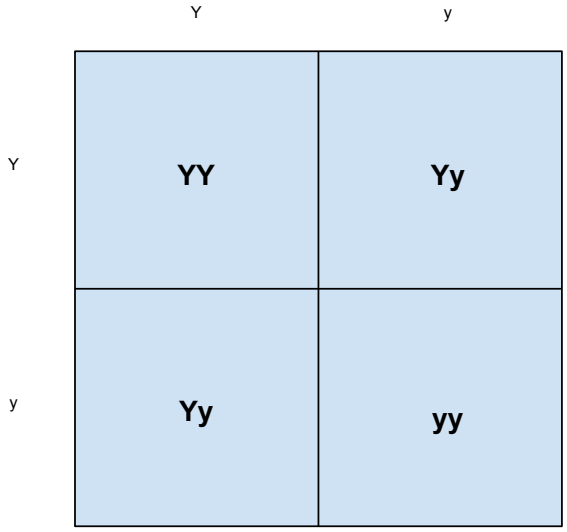
This work contains the solutions to the problem set I of Human Genetics 2015 course at New York University.

Question 1.

Solution. a. As the gamete from the YY pea must be Y, the peas in the F_1 generation must contain a Y allele. Since we are given that YY and Yy genotypes result in yellow color, we have that the peas in the F_1 generation must be yellow. In other words, the expected frequency of yellow peas in the F_1 generation of a cross between YY and yy is 1.

b. In part a, we have reasoned that the peas in the F_1 generation peas must possess a Y allele. Symmetrically, with the presence of yy parent, we can conclude that F_1 generation peas must possess a y allele. Therefore, all peas in the F_1 generation has Yy genotype. We proceed to compute the expected frequency of yellow peas in the F_2 generation through the Punnett Square analysis with two Yy parents.

Figure 1: A Punnett Square with two Yy parents



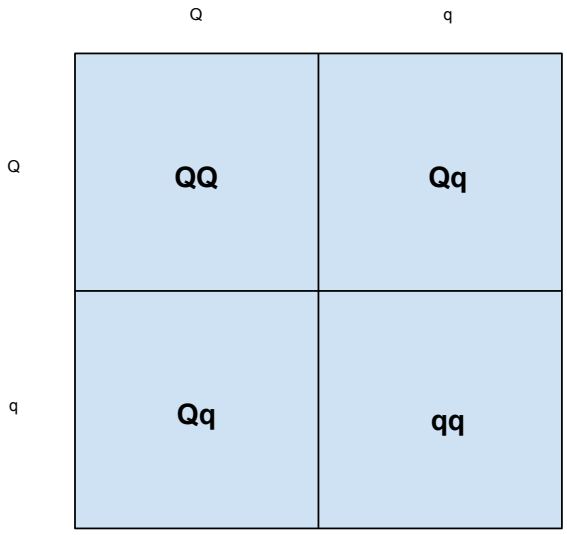
As the yellow color is the dominant trait, the Punnett Square analysis tells us that the expected frequency of yellow peas in the F_2 generation of the cross is 0.75.

c. First of all, as the inheritence of R locus and Y locus are independent for peas, the extra information about R locus is simply irrelevant. In the previous part, we computed that the expected frequency of yellow peas in the F_2 generation of the cross is 0.75. The expected frequency of green peas in the F_2 generation of the cross is $1 - 0.25$, as the sum of the expected freuqnecy of all outcomes must be 1 and green and yellow are the only outcomes allowed for color. Hence, the expected frequency of green peas in the F_2 generation of the cross is 0.25.

Question 2.

Solution. We first begin our analysis with a Punnett Square, with two heterozygous parents.

Figure 2: A Punnett Square with two heterozygous parents



From the Punnett Square, we observe that the probability of the child having QQ or qq genotype, denoted as $P(QQ)$ or $P(qq)$ respecitvely, are both $\frac{1}{4}$. There are now two possible cases that satisfy the given constraint of zero alleles common between the siblings at the locus. The probability space under consideration can be described as the sample space being the set of all possible outcomes of birth of two sibilings. The particular set of events, for which we wish to compute the probability of is two sibilings having zero alleles in common. In the first case, the first child has QQ genotype and the second child has qq genotype. As these events are independent of one another, we obtain that the probability of this case is $P(QQ)P(qq) = \frac{1}{4} \cdot \frac{1}{4} = \frac{1}{16}$. Now, for the second case the first child has qq genotype and the second child has the QQ genotype. As this case is symmetric with the above case, we have the $\frac{1}{16}$ probability again. Hence, the total probability is $\frac{1}{16} + \frac{1}{16} = \frac{1}{8}$. The probability that two siblings, if both of their parents are heterozygous at the locus, will have zero alleles in common at that locus is $\frac{1}{8}$.

Question 3.

Solution. a. As the father is type AB, we know that his genotype is $I^A I^B$. For the case of the mother, since O is the recessive trait, her genotype is $I^O I^O$.

b. The genotype of their children can be either $I^A I^O$ or $I^B I^O$. Since I^A and I^B are both dominant to I^O, the phenotype of their children can be either A or B.

c. Since the father is type A, he can have either $I^A I^A$ or $I^A I^O$ for his genotype. As the mother is type B, she can have either $I^B I^B$ or $I^B I^O$. We see that the possible genotypes of their children, created through the process of segregation, are $I^A I^O$, $I^B I^O$, $I^A I^B$, and $I^O I^O$, which respectively corresponds to the phenotype A, B, AB and O. Hence, the possible blood types among their children are A, B, AB, and O.

Question 4.

Solution. a. Notice that none of the parents possess a I^B allele. As the AB phenotype requires a possession of a I^B allele, their first child cannot have the phenotype AB for the I locus. Hence, the probability that their first child will have the phenotype $AB+$ is 0.

b. Notice that one parent has DD genotype for the Rh locus. Hence, their first child will always possess a D allele, which makes the recessive trait $Rh-$ not a possibility. Therefore, the probability that their first child will have the phenotype $A-$ is 0.

c. The possible genotype for the I locus, in this case, is $I^A I^A$, and $I^A I^O$, both of which correspond to the phenotype A. Furthermore, the possible genotype for the Rh locus is DD and Dd, both of which correspond to the phenotype $+$. Therefore, the overall phenotype of their first child is $A+$. Hence, the probability that their first child will have the phenotype $A+$ is 1.