Homework Assignment #1 – Answer Key

Due September 28th

(Note: each question was worth 1.8 pts with total point value of 20 pts)

1) You have three dice: one red (R), one green (G), and one blue (B). When all three dice are rolled at the same time, calculate the probability of the following outcomes:

   Answer: Each die has six sides, so the probability of any one side (number) is 1/6. To get specific red, green, and blue numbers involves “and” statements:

   a) 6 (R), 6 (G), 6 (B)
       \[ \frac{1}{6} \times \frac{1}{6} \times \frac{1}{6} = \frac{1}{6^3} = \frac{1}{216} = 0.0046 \text{ or } 0.46\% \]

   b) 6 (R), 5 (G), 4 (B)
       \[ \frac{1}{6} \times \frac{1}{6} \times \frac{1}{6} = \frac{1}{6^3} = \frac{1}{216} = 0.0046 \text{ or } 0.46\% \]

   c) no sixes at all
       \[ \left(1 - \frac{1}{6}\right) \times \left(1 - \frac{1}{6}\right) \times \left(1 - \frac{1}{6}\right) = \left(\frac{5}{6}\right)^3 = 0.58 \text{ or } 58\% \]

   d) three sixes or three fives
       \[ p(\text{three sixes or three fives}) = \frac{1}{6}^3 + \frac{1}{6}^3 = 2\left(\frac{1}{6}\right)^3 = 0.0092 \text{ or } 0.92\% \]

   e) the same number on all dice (hint: consider all six possibilities)
       \[ 6\left(\frac{1}{6}\right)^3 = 0.028 \text{ or } 2.8\% \]

   f) on a single die, rolling 2 sixes out of 4 tries

       \[ p = \frac{n!}{x!(n-x)!} p^x q^{n-x} \]

       where n= total # of events; x= # of events in one category; p = individual probability of x; q = individual probability of other category

       \[ p = \frac{4!}{2!(4-2)!} \left(\frac{1}{6}\right)^2 \left(\frac{5}{6}\right)^2 = \frac{4 \times 3 \times 2 \times 1}{2 \times 1} \left(\frac{1}{36}\right) \left(\frac{25}{36}\right) = \frac{1}{12} \left(\frac{25}{36}\right) = 0.1157 \text{ or } 11.5\% \]

2) When a fruit fly of genotype m⁺/m w⁺/w eb⁺/eb is mated to another fly of identical genotype (where m = miniature wing; w = white eye; and eb = ebony body color), what proportion of the progeny flies will have the phenotype “normal wing, white eye, ebony color”? (Assume the three genes are independent).

   Answer:
   \[ \frac{3}{4} \times \frac{1}{4} \times \frac{1}{4} = \frac{3}{64} = 0.047 \]

3) When a pea plant of genotype Aa Bb produces gametes, what proportion will be Ab? (Assume the two genes are independent).

   Answer ¼
4) A fungus *Melampsora lini* causes a disease known as “flax rust.” Different strains of *M. lini* cause varying degrees of the rust disease. Conversely, different strains of flax are resistant or sensitive to the various varieties of rust. The Bombay variety of flax is resistant to *M. lini*-strain 22 but sensitive to *M. lini*–strain 24. A strain of flax called 770B was just the opposite; it is resistant to strain 24, but sensitive to strain 22. When 770B was crossed to Bombay, all the F1 individuals were resistant to both *M. lini*- strain 22 and – strain 24. When F1 individuals were self-fertilized, the following data were obtained:

43 resistant to strain 22 but sensitive to strain 24  
9 sensitive to strain 22 and strain 24  
32 sensitive to strain 22 but resistant to strain 24  
110 resistant to strain 22 and strain 24

Explain the inheritance pattern for flax resistance and sensitivity to *M. lini* strains.

Answer:
The data are consistent with two genes (let’s call them gene 22 and gene 24) that exist in two alleles each, a susceptible allele and a resistant allele. The observed data approximate a 9:3:3:1 ratio. This is the expected ratio if two genes are involved, and if resistance is dominant to susceptibility.

5) For Mendel’s data shown in Figure 2.8 (pg 27 in Brooker text), conduct a chi square analysis to determine if the data agree with Mendel’s law of independent assortment.

Answer:
If we construct a Punnett square according to Mendel’s laws, we expect a 9:3:3:1 ratio. Since a total of 556 offspring were observed, the expected number of offspring are

\[
\begin{align*}
556 \times \frac{9}{16} &= 313 \text{ round, yellow} \\
556 \times \frac{3}{16} &= 104 \text{ wrinkled, yellow} \\
556 \times \frac{3}{16} &= 104 \text{ round, green} \\
556 \times \frac{1}{16} &= 35 \text{ wrinkled, green}
\end{align*}
\]

If we plug the observed and expected values into the chi square equation, we get a value of 0.51.

\[
\text{Chi squared value} = \sum \frac{(\text{observed} - \text{expect})^2}{\text{expect}} + \text{other classes}
\]

\[
\begin{align*}
&\frac{(315-313)^2}{313} + \frac{(101-104)^2}{104} + \frac{(108-104)^2}{104} + \frac{(32-35)^2}{35} \\
&= 0.51
\end{align*}
\]

There are four categories, so our degrees of freedom equal \(n - 1\), or 3. If we look up our value in the chi square table (see Table 2.1), it is well within the range of expected error if the hypothesis is correct. Therefore, we accept the hypothesis. In other words, the results are consistent with the law of independent assortment.
6) For each of the terms in the left column, choose the best matching phrase in the right column (place the number in the space provided to the left of the letter)

<table>
<thead>
<tr>
<th>Term</th>
<th>Matching Phrase</th>
</tr>
</thead>
<tbody>
<tr>
<td>_4__a. phenotype</td>
<td>1. having two identical alleles of a given gene</td>
</tr>
<tr>
<td>_3__b. alleles</td>
<td>2. the allele expressed in the phenotype of the heterozygote</td>
</tr>
<tr>
<td>_6__c. independent</td>
<td>3. alternate forms of a gene</td>
</tr>
<tr>
<td>_7__d. gametes</td>
<td>4. observable characteristic</td>
</tr>
<tr>
<td>11__e. gene</td>
<td>5. a cross between individuals both heterozygous for 2 genes</td>
</tr>
<tr>
<td>13__f. segregation</td>
<td>6. alleles of one gene separate into gametes randomly with respect to alleles of other genes</td>
</tr>
<tr>
<td>_10__g. heterozygote</td>
<td>7. reproductive cells containing only one copy of each gene</td>
</tr>
<tr>
<td>_2__h. dominant</td>
<td>8. the allele that does not contribute to the phenotype of the heterozygote</td>
</tr>
<tr>
<td>_14__i. F1</td>
<td>9. the cross of an individual of ambiguous genotype with a homozygous recessive individual</td>
</tr>
<tr>
<td>_9__j. test cross</td>
<td>10. an individual with two different alleles of a gene</td>
</tr>
<tr>
<td>12__k. genotype</td>
<td>11. the heritable entity that determines a characteristic</td>
</tr>
<tr>
<td>_8__l. recessive</td>
<td>12. the alleles an individual has</td>
</tr>
<tr>
<td>_5__m. dihybrid cross</td>
<td>13. the separation of the 2 alleles of a gene into different gametes</td>
</tr>
<tr>
<td>_1__n. homozygote</td>
<td>14. offspring of the P generation</td>
</tr>
</tbody>
</table>

7) A third-grader decided to breed guinea pigs for her school science project. She went to a pet store and bought a male with smooth, black fur and a female with rough, white fur. She wanted to study the inheritance of those features, and was sorry to see that the first litter of eight contained only rough, black animals. To her disappointment, the second litter from those same parents contained seven rough, black animals. Soon the first litter had begun to produce F2 offspring, and they showed a variety of coat types. Before long the child had 125 F2 guinea pigs. Eight of them had smooth, white coats, 25 had smooth black coats, 23 were rough and white, and 69 were rough and black.

a. How are the coat color and texture characteristics inherited?

b. What phenotypes and proportions of offspring should the girl expect if she mates one of the smooth white females to and F1 male?

Answer: a) Rough and black are the dominant alleles (R=rough, r=smooth; B= Black, b= white)
b) a 1:1:1:1 ratio of rough, black;; rough, white; smooth, black; smooth, white

8. Human cells normally have 46 chromosomes. For each of the following stages, state the number of chromosomes present in a human cell. (In your answers, count chromatids as well as chromosomes).
A. Metaphase of mitosis
B. Metaphase 1 of meiosis
C. Telophase of mitosis
D. Telophase I of meiosis  
E. Telophase II of meiosis

Answer:

A. 46 chromosomes, each with 2 chromatids = 92 chromatids  
B. 46 chromosomes, each with 2 chromatids = 92 chromatids  
C. 46 chromosomes in each of 2 about to be formed cells, each with 1 chromatid  
(equally acceptable is 92 chromosomes and 92 chromatids)  
D. 23 chromosomes in each of 2 about to be formed cells, each with 2 chromatids  
(equally acceptable is 46 chromosomes and 92 chromatids)  
E. 23 chromosomes in each of 4 about to be formed cells, each with 1 chromatid  
(equally acceptable is 46 chromosomes and 46 chromatids)

9. A wild-type female schmoo who is graceful (G) is mated to a non-wild-type male who is gruesome (g). Their progeny consist of graceful males and gruesome females. Interpret these results and give genotypes.

Answer:
First assume that the cross is autosomal:

P  
G- (graceful female) x gg (gruesome male)  
F1  
1 Gg graceful female  
1 g- female  
1 Gg graceful male  
1 g- male

This cross does not meet the observation, so it must be wrong. The cross cannot be G- X gY (X-linked) because graceful females will result. Next assume that the female is the heterogametic sex (ZW system rather than the XY male determination).

P  
ZG W (graceful female) x ZgZg (gruesome male)  
F1  
1 ZgW gruesome female  
1 ZGZg graceful male

10. In Drosophila, a cross was made between a yellow-bodied male with vestigial (not fully developed) wings and a wild-type female (brown body). The F1 generation consisted of wild-type males and wild-type females. F1 males and females were crossed and the F2 progeny consisted of 16 yellow-bodied males with vestigial wings, 48 yellow-bodied males with normal wings, 15 males with brown bodies and vestigial wings, 49 wild-type males, 31 brown-bodied females with vestigial wings, and 97 wild-type females. Explain the inheritance of these genes based on these results.

Answer: The wing size trait (vestigial) needs to be examined separately from the body color trait (yellow). Vestigial is inherited in a simple Mendelian manner (phenotype ratio 3:1) after
counting up all males and females together (normal wild type = 48 + 49 + 97 = 194 vs vestigial = 16 + 15 + 31 = 62). Therefore it is inherited on an autosome.

Whereas, body color is sex-linked and specifically on the X-chromosome. Note the disappearance of the trait in the F2 females (hemizygous males express the yellow color but females are heterozygote and thus wild type). (note: Y-linked inheritance would dictate that the trait is only observed in males and never skips a generation)

Thus, vestigial wings is autosomal; body color is X-linked recessive.

11. Drosophila females of wild-type appearance but heterozygous for three autosomal genes are mated with males showing three autosomal recessive traits: glassy eyes, coal-colored bodies, and striped thoraces. 1000 progeny of this cross are distributed in the following phenotypic classes:

<table>
<thead>
<tr>
<th>Phenotype Description</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild-type</td>
<td>27</td>
</tr>
<tr>
<td>Striped thorax</td>
<td>11</td>
</tr>
<tr>
<td>Coal body</td>
<td>484</td>
</tr>
<tr>
<td>Glassy eye, coal body</td>
<td>8</td>
</tr>
<tr>
<td>Glassy eye, striped thorax</td>
<td>441</td>
</tr>
<tr>
<td>Glassy eye, coal body, striped thorax</td>
<td>29</td>
</tr>
</tbody>
</table>

A. Draw a genetic map based on this data (include map units – m.u.)
B. Show the arrangement of alleles on the two homologous chromosomes in the parent female.

To initially decipher this problem, examine the progeny numbers to determine the parental allele combinations (this will answer number question B first)

Coal= c  wild type body= c^+
Striped thorax = t  wild type thorax = t^+
Glassy eye = g  wild type eye = g^+

To do this- convert all of the above phenotypes into your nomenclature, but note that we are missing two classes (2^3 = 8 unique phenotypes):

Wild type          (wild type body, wild type thorax, wild type eye) = 27
Striped thorax     (wild type body, striped thorax, wild type eye) = 11
Coal body          (coal body, wild type thorax, wild type eye) = 484 *
Glassy eye, coal body (coal body, wild type thorax, glassy eye) = 8
Glassy eye, striped thorax (wild type body, striped thorax, glassy eye) = 441 *
Glassy eye, coal body, striped thorax (coal body, striped thorax, glassy eye) = 29
Coal body, striped thorax (coal body, striped thorax, wild type eye) = 0
Glassy eye          (wild type body, wild type thorax, glassy eye) = 0
Thus the parentals are:
(\textbf{coal body}, wild type thorax, wild type eye) = 484 *
(wild type body, \textbf{striped thorax}, \textbf{glassy eye}) = 441 *

And the double recombinants (the least frequent) are:
(\textbf{coal body, striped thorax}, wild type eye) = 0
(wild type body, wild type thorax, \textbf{glassy eye}) = 0

If you compare the double recombinants to the parentals to look for the single allele that switched (the middle allele will swap):
(\textbf{coal body}, wild type thorax, wild type eye) = 484 *
(\textbf{coal body, striped thorax}, wild type eye) = 0
In this comparison it is the striped thorax
(wild type body, \textbf{striped thorax}, \textbf{glassy eye}) = 441 *
(wild type body, wild type thorax, \textbf{glassy eye}) = 0
And also in this comparison it is striped thorax

Answer to B: Thus the arrangement of the alleles on the two homologous chromosomes in the parent female is (note the male is recessive for all traits as a tester):

\begin{center}
\begin{tabular}{ccc}
$\text{c}^+$ & $t$ & $g$
\end{tabular}
\end{center}

\begin{center}
\begin{tabular}{cc}
$c$ & $t^+$
\end{tabular} & $g^+$
\end{center}

In continuation of A:
Need to determine the number of recombinants between each pair of genes and then divide by the total number of progeny x 100 = map units (or % recombinants):

c-t (parents are $c^+$ - $t$ and $c$ - $t^+$; so recombinants are $c$ - $t$ and $c^+$ - $t^+$)
$$= 27 + 29 = 56 / 1000 \times 100 = 5.6$$

t-g (parents are $t$- $g$ and $t^+$- $g^+$; so recombinants are $t^+$- $g$ and $t$- $g^+$)
$$= 11 + 8 = 19 / 1000 \times 100 = 1.9$$

Simply add the two distances above to determine the distance between $c$-g since distances are additive: $5.6 + 1.9 = 7.5$