Sample Examination Questions for Exam 1 Material
Biology 3300 / Dr. Jerald Hendrix

Warning! These questions are posted solely to provide examples of past test questions. There is no guarantee that any of these questions will be on any examination in the future. Students are responsible for all of the material covered in lectures, assigned readings, textbook problems, laboratories, and any other assigned work. Since these samples have been taken from several past exams, some questions may be very similar or identical. On short answer, essay questions, and genetics problems, the point values from previous exams have been included to give an indication of approximately how much “weight” was given to a question in the past; however, there is no guarantee that any particular question, format, or point distribution will be used on any examination.

13. Cell division is
(a) mitosis.
(b) meiosis.
(c) assortment.
(d) telophase.
(e) cytokinesis. From the class notes

19. In Drosophila, lobe eye shape and sepia eye color are caused by mutations on separate autosomes. The gene for lobe eye shape is dominant over the wild type allele, and the gene for sepia eye color is recessive to the wild type allele. Two flies, each of which was heterozygous for both genes, were mated. What is the expected phenotypic ratio among the progeny?

(a) 9 lobe: 3 sepia: 3 lobe sepia: 1 wild type
(b) 9 lobe: 3 wild type: 3 lobe sepia: 1 sepia
(c) 9 wild type: 3 lobe: 3 sepia: 1 lobe sepia
(d) 9 sepia: 3 lobe sepia: 3 wild type: 1 lobe
(e) Since the genes are linked, the ratio cannot be predicted.

Since lobe & sepia are on separate chromosomes, they assort independently.
Heterozygous lobe, heterozygous sepia was crossed with heterozygous lobe, heterozygous sepia, so using the shortcut method:

<table>
<thead>
<tr>
<th>Eye Shape</th>
<th>Eye Color</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>¾ Lobe</td>
<td>¾ Wild color</td>
<td>9/16 Lobe, Wild color</td>
</tr>
<tr>
<td>¼ Wild shape</td>
<td>¼ Sepia</td>
<td>3/16 Lobe Sepia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3/16 Wild shape, Wild color</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/16 Wild shape, Sepia</td>
</tr>
</tbody>
</table>

In a Drosophila mutant only the mutant traits are stated, any trait that is not explicitly stated is implied to be “wild type.” Therefore, this is 9 lobe: 3 lobe sepia: 3 wild: 1 sepia, or 9 lobe: 3 wild: 3 lobe sepia: 1 sepia.
The following information pertains to questions 20 and 21.
Two different strains of *Drosophila*, strain A and strain B, each has a recessive mutation that results in abnormally bright red eye color. (Wild type flies have brownish red eye color.) When a homozygous strain A fly is crossed with a homozygous strain B fly, all of the progeny have the dominant wild-type eye color.

20. The most likely genetic information for the results given above is

(a) codominant alleles
(b) incomplete dominance
(c) epistasis
(d) multiple alleles
(e) X linkage

*Look at the two flies that were crossed.*

*Strain A recessive bright red x Strain B recessive bright red
↓
Dominant wild type ???!??*

In order for two different recessive strains to produce the dominant phenotype when they are crossed, they must have been recessive in different genes, not in the same gene. Had they been recessive in the same gene, then the offspring would have also been recessive. Since there are two different recessive genes in strain A and B, each masking the other, this is an example of epistasis. This cross is identical to unknown cross c in the maize lab.

21. The progeny mentioned above were allowed to breed among themselves. What is the phenotypic ratio expected among their offspring?

(a) 3 wild-type: 1 bright red eyes
(b) 1 wild type: 1 bright red eyes
(c) all wild type
(d) all bright red eyes
(e) 9 wild type: 7 bright red eyes

*Work out the genotypes. Let recessive strain A be aa BB, and recessive strain B be AA bb. If a fly has either aa or bb or both, it will have bright red eyes, regardless of other genotypes.*

*Strain A recessive red x Strain B recessive red
aa BB ↓ AA bb
↓ Dominant wild type, Aa Bb
AaBb x Aa Bb
↓
1/16 AA BB, 2/16 Aa BB, 2/16 AA Bb, 4/16 Aa Bb = 9/16 Wild type
1/16 aa BB, 2/16 aa Bb, 1/16 AA bb, 2/16 Aa bb, 1/16 aa bb = 7/16 bright red*
The following information pertains to questions 42 and 43.

A geneticist working at a zoo has spent several years studying coat color in foxes. She found that when two platinum-colored foxes are crossed, litters with both platinum and silver-colored offspring are always produced. Over the years, she collected the following data.

platinum X platinum \(\rightarrow\) 220 platinum foxes and 110 silver foxes

42. Which of the following is the most likely explanation for platinum and silver coat color in foxes?

(a) Silver is homozygous recessive, and platinum can either be homozygous or heterozygous.
(b) Silver is homozygous, platinum is heterozygous, and the platinum allele is lethal when homozygous.
(c) Silver is caused by a homozygous recessive condition in either or both of two separate genes that are interacting epistatically.
(d) Platinum is caused by the recessive allele of an X-linked gene.
(e) There are fewer silver foxes than expected due to double-crossover.

Platinum is an example of a lethal gene. All platinum foxes are heterozygous, Pp; silver is homozygous recessive, pp. A homozygous platinum fox PP will die as an embryo and never be born. Therefore, with the cross shown:

\[
Pp \times Pp \rightarrow \begin{array}{c} 1 \text{ PP} : \\ \text{Die as embryos} \\ 2 \text{ Pp} : \\ \text{Survivors:} \\ 1 \text{ pp} \\ 2/3 \text{ Platinum, 1/3 silver} \end{array}
\]

43. If a platinum fox is crossed with a silver fox, what phenotypic frequency is expected among their progeny?

(a) 3/4 platinum, 1/4 silver
(b) 3/4 silver, 1/4 platinum
(c) 9/16 platinum, 7/16 silver
(d) 1/2 platinum, 1/2 silver
(e) All platinum

Since all platinum foxes are heterozygous, then platinum x silver is Pp x pp, and the offspring are ½ Pp, ½ pp.
44. A pair of chromatids attached at the centromere is
   (a) visible only during interphase.
   (b) a pair of homologous chromosomes.
   (c) the result of the process of anaphase.
   (d) the product of DNA replication. Class notes
   (e) attached to the ribosome.

45. In peas, the gene for green seeds (g) is recessive to its allele for yellow seeds (G). A homozygous green-seed plant was crossed to a homozygous yellow-seed plant. What is the genotype of the progeny?
   (a) All green seeds
   (b) All yellow seeds
   (c) All gg
   (d) All Gg Class notes
   (e) All GG

46. Which of the following statements is true?
   (a) Only gametes are capable of starting and completing the process of meiosis.
   (b) Two diploid gametes combine to form a haploid zygote in the process of fertilization.
   (c) Before meiosis begins, germ line cells are diploid. Class notes.
   (d) Two diploid zygotes combine to form a haploid gamete during the process of fertilization.
   (e) A haploid zygote forms four diploid gametes in the process of meiosis.

47. Color blindness in humans is caused by a recessive X-linked gene. If a woman who is heterozygous for this trait marries a man with normal color vision, one predicts that
   (a) all of their sons would be colorblind.
   (b) 1/2 of their daughters would be colorblind.
   (c) 1/2 of their sons would be colorblind.
   (d) all of their daughters would be heterozygous carriers.
   (e) all of their sons would have normal color vision.

Let N be normal color vision, n be color blindness. Here is the cross:

\[ \text{Nn } ♀ \times \text{ NY } ♂ \rightarrow 1 \text{ NN } ♀ : 1 \text{ Nn } ♀ : 1 \text{ NY } ♂ : 1 \text{ nY } ♂ \]

Notice that I expressed the frequencies as a ratio. The choices refer to either the “sons” or the “daughters” so the ratio format makes it easy to see that half their sons are predicted to be normal vision, half are colorblind.
49. A man with type AB blood is married to a woman with type A blood. No other information about the couple is known to you. What are the possible blood types of their children?

(a) A, B, AB, or O
(b) AB only
(c) A or B only
(d) A or AB only
(e) None of the above

We have to consider that the woman could possibly be heterozygous with the recessive $i^0$ allele, so here is the cross:

$I^A I^B \times I^A i^0 \rightarrow \frac{1}{4} I^A I^A, \frac{1}{4} I^A i^0, \frac{1}{4} I^B I^B, \frac{1}{4} I^B i^0$

This couple could have children with blood types A, AB, or B. Since this combination was not given as a choice, the correct answer is e.

50. A certain species has a haploid chromosome number of 46. What is the diploid chromosome number of this species?

(a) 0
(b) 11.5
(c) 23
(d) 46
(e) 92 From the class notes

27. “Deranged” is a phenotype in *Drosophila* in which the thoracic bristles are disarranged and the wings held vertically upward. Crosses between deranged females and normal males, each from pure stock cultures, result in a 1:1 ratio of normal females to deranged males among the progeny. What does this show?

(a) The gene for deranged is autosomal and dominant.
(b) The gene for deranged is autosomal and recessive.
(c) The gene for deranged is X-linked and dominant.
(d) The gene for deranged is X-linked and recessive.
(e) Deranged is determined by two genes interacting epistatically.

A cross between deranged females and normal males resulted in offspring in which the males and females had different phenotypes (males were deranged, females were normal). This indicates that the deranged gene is X-linked; it also means that the deranged gene is recessive because the male offspring must have received their X chromosome (and the recessive deranged gene) from the deranged female parent, while the normal female offspring got their normal gene on the X chromosome from the normal male parent. Let $D =$ normal and $d =$ deranged. Here is the cross:

$dd \varnothing \times DY \varnothing \rightarrow \frac{1}{2} Dd \varnothing, \frac{1}{2} dY \varnothing$
28. A woman with type O, N, Rh+ blood is married to a man with type A, MN, Rh- blood. They had a child. Unfortunately, there was a mix-up at the hospital. Of the five children listed below, which one could have been conceived by this couple?

(a) AB, MN, Rh+
(b) B, N, Rh-
(c) A, M, Rh+
(d) AB, M, Rh-
(e) O, N, Rh+

Rh is determined by a single gene with two alleles; Rh+ is dominant (RR or Rr) over Rh- (rr). Details about ABO and MN blood groups are given in your lab handout and your class notes. Consider the possible genotypes of the woman and man.

\[
\begin{align*}
&O^iO^ l^N^L^N^ Rr \quad \times \quad A^iA^ l^M^L^N^ rr \\
\end{align*}
\]

For each choice, ask yourself: Could this couple produce this child? Notice how I X'd out the wrong choices to arrive at the correct choice.

Children (a) and (d) are type AB. Since the woman is type O, they can’t have an AB child, ruling out (a) and (d).

Child (b) is type B. Neither the woman nor man has B, so that rules out (b).

Child (c) is type M blood, \( L^M^L^N \). Because the woman in type N, she doesn’t have the M allele, so this rules out child (c).

This leaves child (e), who could have been produced by the couple because the man may be heterozygous \( I^A^O \).

7. What is the relationship between amino acids, peptides, and proteins? You do not have to draw chemical structures, but you can if you want to. (6 pt)

*From the class notes*

8. Compare and contrast the secondary, tertiary, and quaternary structures of proteins. (9 pt)

*From the class notes*

9. What is the relationship between protein, DNA, and RNA with respect to the expression of genetic information within the cell? (9 pt)

*From the class notes. In the answer to this question, you should explicitly talk about the concept of sequence information, and you should explicitly define DNA replication, transcription, and translation.*

10. List, in order, and briefly describe the three stages of interphase. (6 pt)

\( G_1, S, G_2 \). A full discussion, including control of the cell cycle, is given in the class notes.

11. List, in order, and briefly describe the four stages of mitosis. (12 pt)

Prophase, metaphase, anaphase, telophase. A full discussion is given in the class notes.
12. Distinguish between “homologous chromosomes” and “chromatids.” In your answer, be sure to include how they behave during meiosis I and meiosis II. (6 pt)

*Complete definitions are given in your class notes.*

13. What effect does colchicine have on mitosis, and why? (4 pt)

*From the class notes.*

14. A certain species has a haploid chromosome number of 46. How many chromosomes would you find in a germ line cell from this species, immediately prior to the beginning of meiosis. (3 pt)

*92. From the class notes.*

15. What is diplonema? (Hint: It is NOT what you get when you graduate.) (3 pt)

*This is one of the stages of Prophase I of meiosis, from the class notes.*

1. In the house plant Coleus, the gene for deep-lobed leaves (D) is dominant over its allele for shallow-lobed leaves (d). A different gene, for leaf venation, has a dominant allele for irregular venation (I) and a recessive allele for regular venation (i). The gene for leaf venation is on a separate homologous chromosome pair from the gene for leaf shape.

For each of the following crosses, what phenotypes are expected among the progeny, and in what frequencies (fractions or ratio)? (4 pt each)

(a) Dd Ii → Dd Ii

*Consider each gene separately, then combine them using the shortcut method.*

<table>
<thead>
<tr>
<th>Leaf shape</th>
<th>Veination</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>¾ Deep</td>
<td>¾ Irregular</td>
<td>9/16 Deep Irregular</td>
</tr>
<tr>
<td>¼ Shallow</td>
<td>¼ Regular</td>
<td>3/16 Deep Regular</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3/16 Shallow Irregular</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/16 Shallow Regular</td>
</tr>
</tbody>
</table>

(b) Dd Ii → dd ii

*Consider each gene separately, then combine them using the shortcut method.*

<table>
<thead>
<tr>
<th>Leaf shape</th>
<th>Veination</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>½ Deep</td>
<td>½ Irregular</td>
<td>¼ Deep Irregular</td>
</tr>
<tr>
<td>½ Shallow</td>
<td>½ Regular</td>
<td>¼ Deep Regular</td>
</tr>
<tr>
<td></td>
<td></td>
<td>¼ Shallow Irregular</td>
</tr>
<tr>
<td></td>
<td></td>
<td>¼ Shallow Regular</td>
</tr>
</tbody>
</table>
2. A geneticist working at a certain zoo has spent several years studying coat color in foxes. She discovered that when two platinum-colored foxes were crossed, some of the offspring had platinum-colored coats and some had silver-colored coats. Over the years, she collected the following data.

\[
\text{platinum} \times \text{platinum} \rightarrow 220 \text{ platinum foxes, 110 silver foxes}
\]

(a) Explain the inheritance of platinum and silver color in foxes. In your answer, define symbols for alleles, and state the genotypes for platinum and silver. (6 pt)

See earlier multiple choice version of this same problem.

(b) If a platinum fox is crossed with a silver fox, what is the expected frequency of platinum foxes among the offspring? (2 pt)

3. The color of spotted cattle is controlled by an autosomally-linked, sex-influenced gene. The gene M produces mahogany-and-white spots, and it is dominant in bulls (male cattle). Its allele, m, is responsible for red-and-white spots, and it is dominant in cows (female cattle). A red-and-white spotted bull was crossed with a mahogany-and-white spotted cow. The cow gave birth to a single calf with red-and-white spots.

(a) What are the genotypes of the cow, the bull, and the calf? (6 pt)

A sex-influenced gene is an autosomal gene in which one allele is dominant in males, and another allele is dominant in females. There are several examples of sex-influenced traits, such as baldness in humans (recessive in females, dominant in males); the presence of horns in sheep (recessive in females, dominant in males). Here we have color spots in cattle. The genotypes and phenotypes are:

<table>
<thead>
<tr>
<th></th>
<th>♂</th>
<th>♀</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM</td>
<td>Mahogany</td>
<td>Mahogany</td>
</tr>
<tr>
<td>Mm</td>
<td>Mahogany</td>
<td>Red</td>
</tr>
<tr>
<td>mm</td>
<td>Red</td>
<td>Red</td>
</tr>
</tbody>
</table>

For a bull (male) to be red, it must be homozygous mm; for a cow to be mahogany, it must be homozygous MM. The calf, therefore, must be heterozygous. Here is the cross:

\[
\text{mm } ♂ \times \text{MM } ♀ \rightarrow \text{Mm}
\]

(b) What is the sex of the calf? (2 pt)

Since the calf is heterozygous Mm and it has red-and-white spots, it must be female.
4. In tomatoes, round fruit shape (R) is dominant over long (r). Smooth fruit skin (P) is dominant over peachy skin (p). Consider the following hypothesis.

Hypothesis: In tomatoes, the gene for fruit shape (R or r) assorts independently of the gene for fruit skin texture (P or p).

A heterozygous round, heterozygous smooth plant was crossed with a long, peachy plant. The following progeny were obtained.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>smooth round</td>
<td>246</td>
<td>140.75</td>
<td>105.25</td>
<td>11077.56</td>
</tr>
<tr>
<td>peachy long</td>
<td>266</td>
<td>140.75</td>
<td>125.25</td>
<td>15687.56</td>
</tr>
<tr>
<td>smooth long</td>
<td>24</td>
<td>140.75</td>
<td>-116.75</td>
<td>13630.56</td>
</tr>
<tr>
<td>peachy round</td>
<td>27</td>
<td>140.75</td>
<td>-113.75</td>
<td>12939.06</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>563</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Do the data support the hypothesis? If not, propose an alternate explanation of the data. In your answer, use the $\chi^2$ test. Show your work. (7 pt)

The question asks if the genes for tomato shape & skin texture assort independently, and it gives the result of a testcross to test this hypothesis. Here is the cross:

$Rr \text{ Pp} \times rr \text{ pp} \rightarrow \frac{1}{4} Rr \text{ Pp}, \frac{1}{4} Rr \text{ pp}, \frac{1}{4} rr \text{ Pp}, \frac{1}{4} rr \text{ pp}$

Notice that with independent assortment in a testcross, you expect a 1:1:1:1 ratio.

Here is the chi-square analysis:

$\chi^2 = 378.93, df = 3; \chi^2 > 11.34, so P < 0.01$ and the deviation is highly significant. The data indicate that the genes for shape and texture DO NOT assort independently. The most likely explanation is that the genes for shape and texture are linked (located on the same chromosome).
5. There are several mutations in *Drosophila* which cause bright red eye color. The wild-type eye color is brownish-red.

In two different bright-red-eyed strains of *Drosophila*, it was discovered that the bright red eye color is recessive to the wild-type. When these two strains were crossed, the following results were obtained.

**P:** Strain A bright red females X Strain B bright red males

**F\(_1\):** All wild type. These were allowed to interbreed.

**F\(_2\):**
- 6/16 Wild type females
- 3/16 Wild type males
- 5/16 Bright red-eyed males
- 2/16 Bright red-eyed females

(a) On the basis of the data given above, do the genes for eye color exhibit codominance, incomplete dominance, X-linkage, lethality, epistasis, pleiotropy, multiple alleles, incomplete penetrance, or monomorphism? (Note: More than one of the choices may be correct.) (4 pt)

*Epistasis and X-linkage. Strain A is recessive in one gene, strain B in a different gene (see explanation, multiple choice question 20, pg 2). Looking at the *F\(_2\)* data, we see that there is a different frequency among the phenotypes for males and females, meaning that one of the two genes must be an X-linked gene.*

(b) Define symbols for the genes and give genotypes for the flies in the P, F\(_1\), and F\(_2\) generations outlined above. (10 pt)

*Since all of the *F\(_1\)* flies are dominant wild type, then the P generation male must have the recessive X-linked gene. Therefore, we can write the genotypes of the P generation as:*

**P:** \(aa\) \(BB\) ♀ × \(AA\) \(bY\) ♂

**F\(_1\):** \(Aa\) \(Bb\) ♀ \(Aa\) \(BY\) ♂

**F\(_2\):** Combined

\[
\begin{array}{ccc}
1/4 AA & 1/4 BB ♀ & 1/16 AA BB wild ♀ \\
2/4 Aa & 1/4 Bb ♀ & 1/16 AA Bb wild ♀ \\
1/4 aa & 1/4 BY ♀ & 1/16 AA BY wild ♀ \\
& 1/4 bY ♀ & 1/16 AA bY red ♀ \\
& & 2/16 Aa BB wild ♀ \\
& & 2/16 Aa BY wild ♀ \\
& & 2/16 Aa bY red ♀ \\
& & 1/16 aa BB red ♀ \\
& & 1/16 aa Bb red ♀ \\
& & 1/16 aa BY red ♀ \\
& & 1/16 aa bY red ♀ \\
\end{array}
\]

*Adding the phenotypes, we get 6/16 wild females, 3/16 wild males, 5/16 red males, and 2/16 red females.*
6. Feather color in chickens can be either blue, black, or splashed-white. These colors are produced by a single autosomal gene with two alleles. If a black chicken is crossed with a splashed-white chicken, all of the progeny are blue. If two blue chickens are crossed, they produce progeny with a ratio of 1:2:1 black:blue:splashed-white.

Comb shape in chickens can be either pea-combed or single-combed. These shapes are produced by a single autosomal gene with two alleles. If a homozygous pea-combed chicken is crossed with a single-combed chicken, all of the F\textsubscript{1} progeny are pea-combed. If the F\textsubscript{1} pea-combed chickens are interbred, they produce progeny with a ratio of 3:1 pea:single in the F\textsubscript{2}.

(a) List the possible dominance relationships that exist between the two alleles for feather color. (2 pt) *Feather color could be due to either codominance or incomplete dominance. We would need more data about the functional gene products to distinguish between these possibilities.*

(b) List the possible dominance relationships that exist between the two alleles for comb shape. (2 pt) *Pea comb is completely dominant over single.*

(c) A geneticist performed the following cross to determine if the genes for feather color and comb shape assort independently.

\[ \text{P: Homozygous pea-combed, black feathers} \]
\[ \times \]
\[ \text{Single-combed, splashed-white feathers} \]
\[ \downarrow \]
\[ \text{F}_1: \text{All pea-combed, blue feathers} \]
\[ \hspace{1cm} \text{F}_1 \times \text{F}_1 \]
\[ \downarrow \]
\[ \text{F}_2: 58 \text{ pea-combed, black chickens} \]
\[ 118 \text{ pea-combed, blue chickens} \]
\[ 66 \text{ pea-combed, splashed-white chickens} \]
\[ 21 \text{ single-combed, black chickens} \]
\[ 39 \text{ single-combed, blue chickens} \]
\[ 18 \text{ single-combed, splashed-white chickens} \]

Do the genes for comb shape and feather color assort independently? Use the $\chi^2$ method to test this hypothesis. Show your work. You may write your answer on the back of the page. (5 pt)
The expected F$_2$ frequencies are:

<table>
<thead>
<tr>
<th>Comb</th>
<th>Color</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>¾ Pea</td>
<td>¼ Black</td>
<td>3/16 Pea Black</td>
</tr>
<tr>
<td>¼ Single</td>
<td>2/4 Blue</td>
<td>6/16 Pea Blue</td>
</tr>
<tr>
<td></td>
<td>¼ White</td>
<td>3/16 Pea White</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/16 Single Black</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2/16 Single Blue</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/16 Single White</td>
</tr>
</tbody>
</table>

Here's the chi square:

<table>
<thead>
<tr>
<th></th>
<th>O</th>
<th>E</th>
<th>O-E</th>
<th>(O-E)$^2$</th>
<th>(O-E)$^2$/E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pea Black</td>
<td>58</td>
<td>60</td>
<td>-2</td>
<td>4</td>
<td>0.067</td>
</tr>
<tr>
<td>Pea Blue</td>
<td>118</td>
<td>120</td>
<td>-2</td>
<td>4</td>
<td>0.033</td>
</tr>
<tr>
<td>Pea White</td>
<td>66</td>
<td>60</td>
<td>6</td>
<td>36</td>
<td>0.600</td>
</tr>
<tr>
<td>Single Black</td>
<td>21</td>
<td>20</td>
<td>1</td>
<td>1</td>
<td>0.050</td>
</tr>
<tr>
<td>Single Blue</td>
<td>39</td>
<td>40</td>
<td>-1</td>
<td>1</td>
<td>0.025</td>
</tr>
<tr>
<td>Single White</td>
<td>18</td>
<td>20</td>
<td>-2</td>
<td>4</td>
<td>0.200</td>
</tr>
<tr>
<td></td>
<td>320</td>
<td></td>
<td></td>
<td></td>
<td>$\chi^2 = 0.975$</td>
</tr>
</tbody>
</table>

At df = 5, the chi square value we have calculated is less than 1.145, so the P value is greater than 0.95, and the deviation is NOT significant. Therefore, the genes for comb shape and feather color assort independently.
7. A woman with blood types O, MN, Rh\(^+\) was married to a man with blood types AB, N, Rh\(^-\). They had a child. Unfortunately, there was a mixup at the hospital. One of the following children, whose blood types are listed below, belongs to the couple.

<table>
<thead>
<tr>
<th>Child #1</th>
<th>Child #2</th>
<th>Child #3</th>
<th>Child #4</th>
<th>Child #5</th>
<th>Child #6</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>A</td>
<td>A</td>
<td>B</td>
<td>O</td>
<td>O</td>
</tr>
<tr>
<td>N</td>
<td>M</td>
<td>MN</td>
<td>M</td>
<td>MN</td>
<td>MN</td>
</tr>
<tr>
<td>Rh(^+)</td>
<td>Rh(^+)</td>
<td>Rh(^-)</td>
<td>Rh(^+)</td>
<td>Rh(^+)</td>
<td>Rh(^-)</td>
</tr>
</tbody>
</table>

Which child belongs to the couple? Support your answer by briefly explaining why the other children could not have been produced by the couple. (5 pt)

*The answer is #3.*

Again, write down the genotypes of the parents. The mother may be heterozygous for Rh and carry the Rh negative allele (Rr) so we will consider this possibility that she could have an Rh negative baby.

\[ i^o R^d L^M L^N Rr \quad \text{♀} \quad I^A I^B L^N L^N \quad rr \quad \text{♂} \]

The couple can’t have an AB baby because the child must get \( i^o \) from the mother, so we cross off child 1. They can’t have an O child because the father doesn’t have an \( i^o \) allele, so we can eliminate child 5 and child 6 from consideration. Child #2 & #4 are both type M, which is homozygous \( L^M L^M \). Since the father is type N, he cannot produce a type M child, so that eliminates both 2 and 4, leaving child #3.

5. How do the sex-determination systems of *Drosophila* and honeybees differ? (4 pt)

*From your class notes.*
6. In wheat, the kernel color may be red, white, or brown. In one experiment, two different strains of brown wheat were crossed with the following results.

\[
P: \quad \text{Brown strain #1} \quad \times \quad \text{Brown strain #2} \quad \downarrow \quad \text{F}_1: \quad \text{All Red Wheat} \quad \text{F}_1 \quad \times \quad \text{F}_1 \quad \downarrow \quad \text{F}_2: \quad \frac{9}{16} \text{ Red Wheat} \quad \frac{6}{16} \text{ Brown Wheat} \quad \frac{1}{16} \text{ White Wheat} \]

(a) On the basis of the data given above, do the genes for wheat color exhibit codominance, incomplete dominance, X-linkage, lethality, epistasis, pleiotropy, multiple alleles, incomplete penetrance, or monomorphism? (2 pt)

*Epistasis.* See the earlier epistasis question, pg 2 for an explanation. In this case, \(A\_B\_\) gives red wheat, either \(aa\_B\_\) or \(A\_bb\) gives brown wheat, and \(aa\_bb\) (recessive on both genes) gives white wheat.

(b) Define symbols for the genes and give genotypes for the plants in the \(P\), \(F_1\), and \(F_2\) generations outlined above. (6 pt)

\[
P: \quad \text{aa BB} \quad \times \quad \text{AA bb} \]

\[
\text{F}_1: \quad \text{All Aa Bb} \quad \text{F}_1 \quad \times \quad \text{F}_1 \quad \text{F}_2: \]

<table>
<thead>
<tr>
<th>(A) gene</th>
<th>(B) gene</th>
<th>Combined</th>
<th>Phenotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>¼ AA</td>
<td>¼ BB</td>
<td>1/16 AA BB</td>
<td>Red</td>
</tr>
<tr>
<td>2/4 Aa</td>
<td>2/4 Bb</td>
<td>2/16 AA Bb</td>
<td>Red</td>
</tr>
<tr>
<td>¼ aa</td>
<td>¼ bb</td>
<td>1/16 AA bb</td>
<td>Brown</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2/16 Aa BB</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4/16 Aa Bb</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2/16 Aa bb</td>
<td>Brown</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/16 aa BB</td>
<td>Brown</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2/16 aa Bb</td>
<td>Brown</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1/16 aa bb</td>
<td>White</td>
</tr>
</tbody>
</table>

Adding up the phenotypes, we get \(9/16\) Red, \(6/16\) Brown, and \(1/16\) White.
11. List, in order, and briefly describe the three stages of interphase. (6 pt)

12. Repeat questions.

13. List, in order, and briefly describe the four stages of mitosis. (12 pt)

14. Distinguish between “homologous chromosomes” and “chromatids.” In your answer, be sure to include how they behave during meiosis I and meiosis II. (6 pt)

15. List and briefly describe the 5 stages of prophase I of meiosis. (10 pt)

*From your class notes.*