Objectives for Test Six Chapter 11 - 12 Genetics: (Double Period Test)

You should be able to:
1. Describe Mendel’s Experiments.
   • Explain the advantages of using pea plants in the experiments.
   • Define and distinguish among true-breeding organisms, hybrids, the P generation, the F1 generation, and the F2 generation.
   • Summarize Mendel’s conclusions.
2. Explain and apply Mendel’s Laws of Inheritance based on his observation of pea plants.
3. Define and distinguish between the following pairs of terms:
   • genotype & phenotype
   • dominant allele & recessive allele
   • heterozygous & homozygous
   • monohybrid cross & dihybrid cross
   • Law of Segregation and Law of Independent Assortment
4. Explain how a testcross is performed to determine the genotype of an organism.
5. Describe the inheritance patterns of (be able to make & interpret Punnett squares) of each of the following: (You must be able to work genetics problems efficiently - PRACTICE!!)
   • Dominance (monohybrid & dihybrid)
   • Incomplete Dominance and Co-Dominance
   • Multiple Alleles
   • Sex-Linked Traits (X-linked traits)
   • Autosomal linked genes and calculate the recombination frequency & map distance
6. Explain how the inheritance pattern of blood type (The A, B,O system) is an example of an exception to Mendel’s Laws.
7. Describe each of the blood types, phenotypically and genotypically.
8. Explain how the events of meiosis explain the observations of Gregor Mendel.
9. Explain how the events of meiosis explain the observations of Thomas Hunt Morgan.
10. Show how the events of meiosis can explain the inheritance patterns of unlinked and linked genes.
11. Using human skin color as an example, explain how trait can be polygenic.
12. Distinguish between autosomal inheritance and sex-linked inheritance.
13. Besides the XX, XY system of humans, explain how sex is determined in other organisms like birds, bees, and alligators.
14. Explain the process of X inactivation in humans. Relate this to Barr bodies. How does this help explain why the trimsomies of XXX (Klinefelter’s) and XO (Turner’s) are not fatal like most other trimsomies.
15. Explain the genetic patterns of epistasis and pleiotropy.
16. Give examples in humans and other organisms of how the environment can affect gene expression.
17. Explain and compare various techniques for diagnosing genetic disorders: in utero techniques such as amniocentesis & chorionic villi sampling; preimplantation genetic diagnosis; and newborn screening.
18. Review how mistakes in meiosis (nondisjunction) can lead to zygotes with an abnormal number of chromosomes as in Down syndrome, Klinefelter Syndrome, and Turner Syndrome.
19. Explain and apply the Chi-square statistical method to results obtained from genetic crosses (as in our Drosophila experiment).
   • Properly state a null hypothesis.
   • Given data from genetic crosses, calculate expected values.
   • Calculate the chi-square statistic for observed results and expected values and evaluate it using a table of values.
20. Evaluate the genetic inheritance patterns of human traits using a family pedigree.
   • In a pedigree, explain how to distinguish between recessive and dominant disorders as well as between autosomal and sex-linked patterns.
   • Create a pedigree based on given family phenotypes using the proper symbols for a pedigree
21. For the following human conditions, explain the genetic inheritance pattern and the main significant features of the condition (if discussed in class):
   • Cystic Fibrosis
   • Tay Sachs
   • Huntington’s Chorea
   • Hemophilia
   • Colorblindness
• Muscular Dystrophy
• Marfan's syndrome
• Sickle cell anemia
• PKU
• Retinoblastoma
• Achondroplastic Dwarfism
• Androgen Insensitivity Syndrome
• Down Syndrome, Klinefelter's syndrome, Turner's syndrome
• SCID (Severe Combined Immune Deficiency)
• Prader-Willi syndrome (and Angelman Syndrome) – example of epigenomic inheritance

22. Mitochondria contain DNA. Explain how these genes would be inherited differently than genes in the nucleus.

23. Regarding epigenetics:
• What is it?
• How do the inheritance of Prader-Willi syndrome and Angelman syndrome support the existence of epigenetic inheritance?
• Explain the experiment with agouti mice (blond, obese mice and the brown, thin mice) and a change in diet (foods rich in Vitamin B12 which are used to make methyl tags) that support the existence of epigenetic inheritance.
• How can identical twins be so similar when they are young but quite different when they are older adults?
• Explain how the experiments with licking behavior of mother mice supports the existence of epigenetic inheritance.
• Explain the correlation seen in the Swedish population between diet of grandparents and the health of their grandchildren. How does this support epigenetics?

24. LAB: Using Sordaria to determine the map distance between a gene and the centromere.
• Label a diagram of the Sordaria life cycle.
• Explain why we know the genotype of each spore with regard to spore color.
• Diagram the cross over events (or lack of) that cause various spore patterns in the Sordaria asci (4:4;2:2:2:2 and 2:4:2).
• Explain the relationship between distance between the gene and it's centromere and recombination frequency.
• Count asci spore patterns and use this data to calculate the map distance between the gene for spore color and the centromere. (Why do you divide by 2 when doing this calculation?)
• Given a published map distance calculate the Chi-square statistic to evaluate how well experimental data agrees.
• Compare the translocation that results in the Philadelphia chromosome and leukemia with the crossing over that occurs in Sordaria.
• Design an experiment to evaluate the effect of some environmental factor (light, pH, humidity, space, etc.) has on the crossover frequency in Sordaria.

25. You have many practice genetics problems available in your text and in the binder. Practice many problems so that you become efficient working all types of genetics problems.

26. Even though it is extra credit, I highly recommend doing the study guide for this particular unit, especially the practice problems.

27. Each chapter has some multiple choice questions and a few other additional questions at its end. Give these a try. You might see them again!
**Essay Question:** There will not be a major essay on the genetics tests. Rather, there will be several genetics problems for which you must show your work. The essays below are really large genetics problems:

1. A new species of fly was discovered on an island in the South Pacific. Several different crosses were performed, each using 100 females and 100 males. The phenotypes of the parents and the resulting offspring were recorded.

Cross I: True-breeding bronze-eyed males were crossed with true-breeding red-eyed females. All the F1 offspring had bronze eyes. F1 flies were crossed, and the data for the resulting F2 flies are given in the table below.

<table>
<thead>
<tr>
<th>F2 Phenotype</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronze eyes</td>
<td>3,720</td>
<td>3,800</td>
</tr>
<tr>
<td>Red eyes</td>
<td>1,260</td>
<td>1,320</td>
</tr>
</tbody>
</table>

Cross II: True-breeding normal-winged males were crossed with true-breeding stunted-winged females. All the F1 offspring had stunted wings. F1 flies were crossed, and the data for the resulting F2 flies are given in the table below.

<table>
<thead>
<tr>
<th>F2 Phenotype</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal wings</td>
<td>1,160</td>
<td>1,320</td>
</tr>
<tr>
<td>Stunted wings</td>
<td>3,600</td>
<td>3,820</td>
</tr>
</tbody>
</table>

Cross III: True-breeding bronze-eyed, stunted-winged males were crossed with true-breeding red-eyed, normal-winged females. All the F1 offspring had bronze eyes and stunted wings. The F1 flies were crossed with true-breeding red-eyed, normal-winged flies, and the results are shown in the table below.

<table>
<thead>
<tr>
<th>Phenotype</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronze eyes, stunted wings</td>
<td>2,360</td>
<td>2,220</td>
</tr>
<tr>
<td>Bronze eyes, normal wings</td>
<td>220</td>
<td>300</td>
</tr>
<tr>
<td>Red eyes, stunted wings</td>
<td>260</td>
<td>220</td>
</tr>
<tr>
<td>Red eyes, normal wings</td>
<td>2,240</td>
<td>2,180</td>
</tr>
</tbody>
</table>

(a) What conclusions can be drawn from cross I and cross II? Explain how the data support your conclusions for each cross.

(b) What conclusions can be drawn from the data from cross III? Explain how the data support your conclusions.

2. In fruit flies, the phenotype for eye color is determined by a certain locus. E indicates the dominant allele and e indicates the recessive allele. The cross between a male wild-type fruit fly and a female white-eyed fruit fly produced the following offspring:

(a) Determine the genotypes of the original parents (F0 generation) and explain your reasoning. You may use Punnett squares to enhance your description, but the results from the Punnett squares must be discussed in your answer.

<table>
<thead>
<tr>
<th></th>
<th>Wild-type Male</th>
<th>Wild-type Female</th>
<th>White-eyed Male</th>
<th>White-eyed Female</th>
<th>Brown-eyed Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>0</td>
<td>45</td>
<td>55</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
| The wild-type and white-eyed individuals from the F1 generation were then crossed to produce the following offspring:

<table>
<thead>
<tr>
<th></th>
<th>F2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>24</td>
</tr>
</tbody>
</table>

(b) Use a Chi-square test on the F2 generation data to analyze your prediction of the parental genotype. Show all your work and explain the importance of your final answer.

(c) The brown-eyed female in the F1 generation resulted from a mutational change. Explain what a mutation is, and discuss two types of mutations that might have produced the brown-eyed female in the F1 generation.

(You will be provided with a table of chi square values, p values, at several degrees of freedom as well as the formula for calculating for the Chi-square value.)
3. An organism is heterozygous at two genetic loci on different chromosomes.

\[ \text{A} \quad \text{a} \quad \text{B} \quad \text{b} \]

Explain how the behavior of these two pairs of homologous chromosomes during meiosis provides the physical basis for Mendel's two laws of inheritance. (This could be a short answer question.)

4. Assume that a particular genetic condition in a mammalian species causes an inability to digest starch. This disorder occurs with equal frequency in males and females. In most cases, neither parent of affected offspring has the condition. Describe the most probably pattern of inheritance for this condition. Explain your reasoning. Include in your discussion a sample cross(es) sufficient to verify your proposed pattern.

5. State the conclusions reached by Mendel in his work on the inheritance of characteristics. Explain how each of the following deviated from these conclusions: (Each of these could be a short answer question by itself.)
   a. Autosomal linkage
   b. Sex-linked (X-linked) inheritance
   c. Polygenic (multiple-gene) inheritance

6. Discuss the following phenomena in which the sex chromosomes are involved with particular reference to their significance or consequence in humans. (Each of these could be a short answer question by itself.)
   a. Sex determination
   b. Sex-linked inheritance
   c. Formation of Barr bodies (sex chromatin)
   d. Variation in kinds and numbers of sex chromosomes.
AP Biology Lab: Drosophila Genetics

Introduction:
Drosophila melanogaster, the fruit fly, is an excellent organism for genetics studies because it has simple food requirements, occupies little space, is hardy, completes its life cycle in about 12 days at room temperature, produces large numbers of offspring, can be immobilized readily for examination and sorting, and has many types of hereditary variations that can be observed with low-power magnification. Drosophila has a small number of chromosomes (four pairs). These chromosomes are easily located in the large salivary gland cells. Drosophila exists in stock cultures that can be readily obtained from several sources. Much research about the genetics of Drosophila during the last 50 years has resulted in a wealth of reference literature and knowledge about hundreds of its genes.

The Life Cycle of Drosophila melanogaster (Figure 1)

The eggs are small, oval shaped, and have two filaments at one end. They are usually laid on the surface of the culture medium and, with practice, can be seen with the naked eye. The eggs hatch into larvae after about a day.

The wormlike larva eats almost continuously, and its black mouth-parts can easily be seen moving back and forth even when the larva itself is less distinct. Larvae tunnel through the culture medium while eating; thus, channels are a good indication of the successful growth of a culture. The larva sheds its skin twice as it increases in size. In the last of the three larval stages, the cells of the salivary glands contain giant chromosomes, which may be seen readily under low-power magnification after proper staining.

When a mature larva in a lab culture is about to become a pupa, it usually climbs up the side of the culture bottle or on to the strip provided in the culture bottle. The last larval covering then becomes harder and darker, forming the pupal case. Through this case the later stages of metamorphosis to an adult fly can be observed. In particular, the eyes, the wings, and the legs become readily visible.

When metamorphosis is complete, the adult flies emerge from the pupal case. They are fragile and light in color and their wings are not fully expanded. These flies darken in a few hours and take on the normal appearance of an adult fly. They live a month or more and then die. A female does not mate for about ten to twelve hours after emerging from the pupa. Once she has mated, she stores a considerable quantity of sperm in receptacles and fertilizes her eggs as she lays them. To ensure a controlled mating, it is necessary to use females that have not mated before.

![Figure 1: The Life Cycle of Drosophila melanogaster](image)

It is important to realize that a number of factors determine the length of time of each stage in the lifecycle. Of these factors, temperature is the most important. At room temperature (about 22-25°C), the complete cycle takes ten to twelve days. The genetics experiment will be carried on for several weeks. Drosophila with well-defined mutant traits will be assigned to you and your group. Common inheritance patterns used for these experiments are simple autosomal and sex-linked patterns. To make these experiments interesting and challenging, you will not be told the inheritance pattern you are studying. You are responsible for making observations and accurate record keeping concerning what happens as mutant traits are passed from one generation to the next.

SAFETY CONCERNS
Flies are anaesthetized with a material called Fly Nap. Do not inhale Fly Nap. Although
safe to work with, continued exposure can be irritating to your eyes and nasal passages. This can be avoided by maintaining a ‘reading’ distance between you and the flies. Do not work too closely with the flies.

**Procedure:**
1. **First Week.** Obtain a vial of wild type flies. Practice immobilizing and sexing these flies. Examine these flies with regard to eye color and wing shape.

2. Distinguish male flies from female flies by looking of the following characteristics with a microscope. Males are usually smaller than females. Makes have dark, blunt, posteriors, whereas the females have lighter pointed posteriors. The males have sex combs, which are groups of black bristles on the uppermost joint of the forelegs, whereas the females do not. See Figure 2. Note whether the mutation(s) is/are associated with the males or the females. Identify the mutation(s) and give it/them a made-up name and gene symbol. Confirm your findings with the teacher.

**Figure 2: Female and male characteristics of Drosophila (See the larger diagram in your handouts)**

3. Obtain a vial containing pairs of experimental flies. Record the number/phenotype of the vial. This number will serve as a record as to which flies you have obtained. These flies are the parental generation (P) and have already mated. The females should have already laid eggs on the surface of the culture medium. Follow the instructor’s instructions on how to set up and label a culture tube. Take 3-5 flies of each gender and place in your sub-culture vial. An example of the label is as follows: if a curly-winged female is crossed with a straight-winged male, the label could read: “curly X straight”. Also be sure to label the vial with your group name, date, and vial number. Place the vial in the “nursery”.

4. **Second—Third Week.** By this time, you should have eggs or larvae on the side of your subculture vial. Immobilize and remove the adult parent flies. Place the parents in the morgue (an alcohol filled jar).

5. **Third Week.** As soon as you start seeing adults, you must isolate the females before they start to mate. For example, when you notice a few, new adults for the first time, isolate 3-4 females and place in a new, separate vial. Keep your original subculture in the nursery as you might need them later on.

6. Check your new vial every day to see if larvae are crawling around. If so, then your females were very promiscuous in their youth and you have to start over. If, after 5 days or so, you have no larvae, then you can use them as one half of your parental (P) generation.

7. Take your virgin female vial, immobilize them, and place 3-5 immobilized males (of the appropriate stock—depending on which mutation you are studying) into the vial. This is your parental (P) generation. Record appropriate information on the label and also on the Drosophila Record Sheet.

8. **Fourth Week.** Observe your parental generation vial. You should start to see larvae crawling around.

9. **Fourth—Fifth Week.** Now, you should have eggs and larvae on the side of your subculture vial. Immobilize and remove the adult parent flies before the next generation hatches. Place the parents in the morgue (an alcohol filled jar).

10. **Fifth Week.** Begin observing the F1 flies. Immobilize and examine all the flies. Record their sex and the
presence or absence of the mutation(s) (as observed in the parental flies) in the Drosophila Record Sheet. You now can make your hypothesis for this experiment after observing these flies! Consider the conclusions that can be drawn from these data. Place 5 or 6 mating pairs of F1 flies in a fresh culture bottle and the rest of the flies in the morgue. For this cross the females need not be virgin flies. Label the new vial “F1 X F1”. Also, label the vial with symbols denoting the cross, the date, and your name.

11. Sixth—Seventh Week. Observe your F1 generation vial. You should start to see larvae crawling around. Remove the F1 adult flies from the vials and place them in the morgue. The F2 generation flies are the eggs and/or larvae in the vial. Place the vial back into the nursery.

12. Seventh Week. Once you start to see adults hatching, begin removing the F2 flies. Record their sex and the presence or absence or the mutant phenotypes (as observed in the parental flies) in your Drosophila Record Sheet. After they have been counted, place the flies in the morgue. The more F2 flies collected, the more reliable the data will be. You will have to collect F2 flies over a 3 or 4 day period. Try to collect at least 100 flies.
AP Biology Lab: *Drosophila* Identification

**Male**

**Female**

Characteristics

1. Males are smaller overall.

2. Males have a rounded abdomen with a distinct black cap at the posterior end. The abdomen of females have a more pointed shape with a black striped coloration.

3. Males have a dark tuft of bristles on their front forelegs called sex combs.
## Drosophila Data

### Parental Flies Phenotypes:

<table>
<thead>
<tr>
<th>F1 Phenotypes:</th>
<th>F2 Males</th>
<th>F2 Females</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Student Name</th>
</tr>
</thead>
</table>
AP Biology Lab:
GUIDELINES for Drosophila Data Analysis

OVERVIEW: As a class, we worked with four different crosses of Drosophila. They were:

- Cross 1: TBD
- Cross 2: TBD
- Cross 3: TBD
- Cross 4: TBD

For the first three crosses, we are interested in determining:
- Which traits are dominant and which are recessive?
- Are the traits autosomal or sex-linked?
- If the cross involves two traits, do these two traits assort independently or are they linked on the same chromosome?
- If the two traits are linked, what is the map distance between the two genes (based on recombination frequency)?

For cross four we will analyze for something different. These three characteristics (eye color, wing type, and bristle shape) are linked on the same chromosome; in fact, they are linked on the X chromosome. We will analyze our data to determine whether or not our results agree with the published map distances for:

- White eyes and miniature wings
- Miniature wings and forked bristles

DATA PRESENTATION AND ANALYSIS: (See Example) In this section, you will analyze the data from the four genetic crosses. Look at the data and use it to form your hypothesis about the genetics for each cross. For each cross you will need a hypothesis/prediction (use the IF/THEN Form – see example), the genotypes for all generations with a key, Punnett squares for the F2 generation, the expected F2 phenotypic ratio, data tables for the F1 and F2 flies which show the class total observed results along with the expected values which you need to calculate. Write a proper Null Hypothesis at the bottom of your table – There is no significant difference between whatever results where obtained with whatever results where expected), Chi-square calculations, and p-values. [Example Hypothesis: Tan is an autosomal dominant allele for the body color gene. Example Prediction: If tan body color is dominant to black body color and the gene for body color is autosomal, then all male and female F1 flies should be tan and the F2 flies should be 3 tan males: 1 black male: 3 tan females: 1 black female.] If you are evaluating two traits, and you hypothesize that they are linked, you need to calculate the map distance and use then when preparing your expected values and Chi-square values.

DISCUSSION & CONCLUSION: Once you have finished the analysis, you can then turn these numerical values into written thought. Your conclusion restates your hypothesis and goes on to use the analysis to support and accept or reject the hypothesis, in other words, you should use your data, chi-squared values and p-values to support your argument. Discuss the validity of any data that appears “suspect to error.” You should propose possible explanations for the data collected and whether or not this data supports your hypothesis. Be as clear and concise as possible. Don’t forget to truly draw a conclusion: What traits are dominant and recessive; what genes are autosomal and sex-linked; and which genes assort independently and which are linked.
Data Presentation and Analysis for Cross # 52:  
**Female Purple X Male Yellow**

**Hypothesis:** The purple allele for the corn color gene is dominant to the yellow allele and the corn color gene is on an autosome.

**Prediction:** If the purple allele is autosomal dominant to the yellow allele, then the parental cross between homozygous purple and homozygous yellow will yield all purple progeny in the F1 generation and a cross between the F1 progeny will yield three purple kernels to every one yellow kernel.

**Allele key for the alleles:** $P = $ purple; $p = $ yellow  
**Parental Genetic Cross:** $\varnothing PP \times \delta pp$

**F1 Generation**  
**Table 1: Punnett Square of the P1 Genetic Cross (shows F1 Progeny)**

\[
\begin{array}{c|c|c}
\hline
& P & P \\
\hline P & Pp & Pp \\
\hline P & Pp & Pp \\
\hline
\end{array}
\]

**Expected Phenotypic Ratio F1 Progeny:** All Purple

**F2 Generation**  
**Table 2: Punnett Square of the F1 Genetic Cross (shows F2 Progeny)**

\[
\begin{array}{c|c|c}
\hline
& P & P \\
\hline P & PP & Pp \\
\hline P & Pp & PP \\
\hline
\end{array}
\]

**Expected Phenotypic Ratio F2 Progeny:** 3 Purple : 1 Yellow

**Table 3: F1 Progeny Results (shows F1 offspring)**

<table>
<thead>
<tr>
<th>Phenotype</th>
<th>Purple</th>
<th>Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed Results</td>
<td>584</td>
<td>216</td>
</tr>
<tr>
<td>Expected Results</td>
<td>600</td>
<td>200</td>
</tr>
</tbody>
</table>

**Null Hypothesis:** There is no significant difference between the expected 600 purple corn kernels and the 584 purple observed corn kernels and the expected 200 yellow corn kernels and the 216 yellow observed corn kernels.

**Equation 2: Chi square analysis of the F1 Progeny**

\[
X^2 = \frac{(584 - 600)^2}{600} + \frac{(216-200)^2}{200}
\]

\[
X^2 = .43 + 1.28
\]

\[
X^2 = 1.71
\]

$.50 > p$ value $> .20$  
Accept Null Hypothesis

**Conclusion Paragraph:**
AP Biology: Chi-Square Practice Problem: Application of Chi-Square to Genetics

An investigator observes that when pure-breeding, long-wing Drosophila are mated with pure-breeding, short-winged flies, the F1 offspring have an intermediate wing length.

When several intermediate-wing-length flies are allowed to interbreed, the following results are obtained:

<table>
<thead>
<tr>
<th>Observed</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Long Wings</td>
<td>230</td>
</tr>
<tr>
<td>Intermediate Wings</td>
<td>510</td>
</tr>
<tr>
<td>Short Wings</td>
<td>260</td>
</tr>
</tbody>
</table>

1. What is the genotype of the F1 intermediate wing-length flies?

2. Write an experimental hypothesis describing the mode of inheritance of sing length in Drosophila?

3. What would the null hypothesis be for this experiment?

4. Calculate the expected values and the chi square value for these data. Use the table below.

<table>
<thead>
<tr>
<th>Calculation of the Chi-Square Value</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Observed (O)</td>
<td>Expected (E)</td>
<td>((O-E)^2/E)</td>
</tr>
<tr>
<td>Long Wings</td>
<td>230</td>
<td></td>
</tr>
<tr>
<td>Intermediate Wings</td>
<td>510</td>
<td></td>
</tr>
<tr>
<td>Short Wings</td>
<td>260</td>
<td></td>
</tr>
</tbody>
</table>

\[ X^2 = \]

5. How many degrees of free are there?

6. Evaluate the Chi-square value. Does the data cause you to reject or not reject the null hypothesis? What can you conclude about the experimental hypothesis?
1. As Mendel discovered, gray seed color in peas is dominant to white. In the following experiments, parents with known phenotypes but unknown genotypes produced the listed progeny:

<table>
<thead>
<tr>
<th>Parents</th>
<th>GRAY</th>
<th>WHITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRAY X WHITE</td>
<td>82</td>
<td>78</td>
</tr>
<tr>
<td>GRAY X GRAY</td>
<td>118</td>
<td>39</td>
</tr>
<tr>
<td>WHITE X WHITE</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>GRAY X WHITE</td>
<td>74</td>
<td>0</td>
</tr>
<tr>
<td>GRAY X GRAY</td>
<td>90</td>
<td>0</td>
</tr>
</tbody>
</table>

3. Using the letter G for the gray gene and g for white, give the most probable genotype of each parent.

4. In crosses (B), (D), and (E) of problem 1, indicate how many of the gray progeny produced by each cross would be expected to produce white progeny when self-fertilized.

5. Brachydactyly is a rare human trait that causes a shortening of the fingers. Various investigations have shown that approximately half the progeny of brachydactyly X normal marriages are brachydactylyous and never is a child brachydactyous unless at least one parent is. What proportion of brachydactyous offspring would be expected in matings between two brachydactyous individuals each of whom had at least one normal parent.

6. Assume that eye color in humans is controlled by a single pair of alleles of which the effect of that for brown (B) is dominant over the effect of that for blue (b). What is the genotype of a brown-eyed individual who marries a blue-eyed individual and produces a first offspring that is blue-eyed. For the same mating as listed, what proportions of the two eye colors are expected among further offspring? What are the expected proportions of eye colors among the offspring of a mating between two brown-eyed individuals who each had one parent that was blue-eyed?

7. Sickle cell anemia (SCA) is a human genetic disorder caused by a recessive allele. A couple plans to marry and want to know the probability that they will have an affected child. With your knowledge of Mendelian inheritance, what would you tell them if (a) both are normal but each has one affected parent and the other has no family history of SCA; or (2) the man is affected by the disorder, but the woman has no family history of SCA?

8. If you are informed that being right- or left-handed is heritable and that a right-handed couple is expecting a child, can you conclude that the child will be right-handed?

9. Stem length in pea plants is controlled by a single gene. Consider the cross of a true-breeding, long-stemmed variety to a true-breeding, short-stemmed variety in which long stems are completely dominant.
   a. If 120 F1 plants are examined, how many plants are expected to be long-stemmed? Short-stemmed?
   b. Assign genotypes to both F1 varieties and to all phenotypes listed in (a).
   c. A long-stemmed F1 plant is self-crossed. Of 300 F2 plants, how many should be long-stemmed? Short-stemmed?
   d. For the F2 plants mentioned in (c), what is the expected genotype ratio?
AP Biology Genetics Problems Set 2: 
Test Crosses 

1. In rabbits, brown coat is dominant and white color is recessive. Suppose you have a group of rabbits -- some brown and some white.  
   a. For which phenotype(s) do you know the genotype(s)?  
   b. For which phenotypes are you unsure of the genotype(s)?  
   c. Using B and b to symbolize the brown and white alleles, what are the possible genotypes of a white rabbit in your group?  
   d. What are the possible genotypes of a brown rabbit in your group?  
   e. Suppose you want to find out the genotype of a brown rabbit. What color rabbit would you mate it with?  
2. A brown buck (male) is mated with a white doe (female). In their litter of 11 young, six are white and five are brown.  
   f. Using a Punnett square to check your answer, what is the genotype of the buck?  
   g. Use a Punnett square to figure out the ratio of brown and white offspring that would have been produced by the above mating if he brown buck had been homozygous?  
3. If half the offspring from a test cross are of the dominant phenotype and half are of the recessive phenotype, is the parent of the individual who expresses the dominant phenotype, and has the unknown genotype, homozygous or heterozygous?  
4. If all the offspring from a test cross are of the dominant phenotype, is the parent with the dominant phenotype (but unknown genotype) homozygous or heterozygous?  

Additional problems: See your textbook.
AP Biology Genetics Problems Set 3: Dihybrid Genetics Problems

1. Organisms have the following genotypes. What types of gametes can these organisms produce and in what proportions?
   a. Aabb
   b. AAbb
   c. AaBb

2. In garden peas the effect of the tall allele (T) is dominant over that for short (t), and the effect of the smooth-seeded allele (W) is dominant over that for wrinkled (w). These two gene pairs are also known to assort independently of each other. What proportions of phenotypes would you expect among the progeny of tall smooth-seeded F1 plants crossed to each other if each such F1 plant were derived from a cross between a pure breeding tall smooth-seeded variety (TTWW) and a short wrinkled-seeded variety (ttww)? Would the proportions of phenotypes in the F2 generation be changed if the F1 plants were derived from a cross between a tall wrinkled-seeded variety (TTww) and a short smooth-seeded variety (ttWW)? What phenotypic results would you expect if the F1 plants in question 1 were crossed to a short wrinkled-seeded plant?

3. In dogs dark coat color is dominant over albino, and short hair is dominant over long hair. If these effects are caused by two independently segregating gene pairs, write the most probable genotypes for the parents of each of the following crosses, using the symbols D and d for the dark and albino coat-color alleles, and H and h for the short and long-hair alleles, respectively.

<table>
<thead>
<tr>
<th>PARENTAL TYPES</th>
<th>DARK SHORT</th>
<th>DARK LONG</th>
<th>ALBINO SHORT</th>
<th>ALBINO LONG</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) DARK SHORT X DARK SHORT</td>
<td>89</td>
<td>31</td>
<td>29</td>
<td>11</td>
</tr>
<tr>
<td>b) DARK SHORT X DARK LONG</td>
<td>18</td>
<td>19</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>c) DARK SHORT X ALBINO SHORT</td>
<td>20</td>
<td>0</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>d) ALBINO SHORT X ALB SHORT</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>9</td>
</tr>
<tr>
<td>e) DARK LONG X DARK LONG</td>
<td>0</td>
<td>32</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>f) DARK SHORT X DARK SHORT</td>
<td>46</td>
<td>16</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>g) DARK SHORT X DARK LONG</td>
<td>29</td>
<td>31</td>
<td>9</td>
<td>11</td>
</tr>
</tbody>
</table>

4. In 1901 Bateson reported the first post-Mendelian study of a cross differing in two characters. White Leghorn chickens, having large single combs and white feathers, were crossed to Indian Game Fowl, with small pea combs and dark feathers. The F1 was white with pea combs. A cross F1 x F1 produced the following F2: 111 white pea, 37 white single, 34 dark pea, 8 dark single. What numbers of each would you have expected? Test your explanation statistically, using the chi-square method.

5. If two gene pairs A and B are assorting independently with A dominant to a and B dominant to b, what is the probability of obtaining: An AB gamete from an AaBb individual? An AB gamete from an AABB individual? An AABB zygote from a cross AaBb x AaBb? An AABB zygote from a cross aabb x AABB?

6. Organisms have the following genotypes. What types of gametes will these organisms produce and in what proportions?
   a. Aabb
   b. AAbb
   c. AaBb
7. Two traits are simultaneously examined in a cross of two pure-breeding pea-plant varieties. Pod shape can be either swollen or pinched. Seed color can be either green or yellow. A plant with the traits swollen and green is crossed with a plant with the traits pinched and yellow, and a resulting F1 plant is self-crossed. A total of 640 F2 progeny are phenotypically categorized as follows:

360 swollen and yellow
120 swollen and green
120 pinched and yellow
40 pinched and green

a. What is the phenotypic ratio observed for the pod shape? Seed color?
b. What is the phenotypic ratio observed for both traits considered together?
c. What is the dominance relationship for pod shape? Seed color?
d. Deduce the genotypes of the P1 and F1 generations.

8. Considered the following cross in pea plants, in which smooth seed shape is dominant to wrinkled, and yellow seed color is dominant to green. A plant with smooth, yellow seeds is crossed with a plant with wrinkled, green seeds. The peas produced by the offspring are all smooth and yellow. What are the genotypes of the parents? What are the genotypes of the offspring?

9. Consider another cross in pea plants involving the genes for seed color and shape. As before, yellow is dominant to green and smooth is dominant to wrinkled. A plant with smooth, yellow seeds is crossed to a plant with wrinkled, green seeds. The peas produced by the offspring are as follows: one-fourth are smooth, yellow; one-fourth are smooth, green; one-fourth are wrinkled, yellow; and one-fourth are wrinkled, green.

a. What is the genotype of the smooth, yellow parent?
b. What are the genotypes of the four classes of offspring?

10. Albinism and hair color are governed by different genes. A recessively inherited form of albinism causes affected individuals to lack pigments in their skin, hair and eyes. In hair color, red hair is inherited as a recessive trait, and brown hair is inherited as a dominant trait. An albino woman whose parents both have red hair has two children with a man who is normally pigmented and has brown hair. The brown-haired partner has one parent who has red hair. The first child is normally pigmented and has brown hair. The second child is an albino.

a. What is the hair color (phenotype) of the albino woman?
b. What is the genotype of the albino parent for hair color?
c. What is the genotype of the brown-haired parent with respect to hair color? Skin pigmentation?
d. What is the genotype of the first child with respect to hair color and skin pigmentation?
e. What are the possible genotypes of the second child for hair color? What is the phenotype of the second child for hair color? Can you explain this?

11. Consider the following cross:
P1: AABBCCDDEE x aabbccddeee
F1: AaBbCcDdEe (self-cross to get F2)

What is the chance of getting an AaBBccDdee individual in the F2 generation?

12. In the following trihybrid cross, determine the chance that an individual could be phenotypically A, B, C in the F1 generation.
P1: AaBbCc x AabbCC

13. In pea plants, long stems are dominant to short stems, purple flowers are dominant to white, and round seeds are dominant to wrinkled. Each trait is determined by a single, different gene. A plant that is heterozygous at all three loci is self-crossed, and 2,048 progeny are examined. How many of these plants would you expect to be long-stemmed with purple flowers, producing wrinkled flowers?

Additional problems: See your text.
AP Biology Genetics Problems Set 4:

Multiple Alleles and Co-Dominance Genetics Problems

1. In four o’clock plants, the allele for red flower color has an effect that is incompletely dominant over the effect to the white color allele. If a cross between two plants produced 18 red, 32 pink, and 15 white plants, what are the phenotypes of the parents?

2. What ratios of flower color in four o’clocks would you expect among the offspring of the following crosses: Red X Red, Red X Pink, White X Pink, Pink X Pink.

3. In cattle, the effect of the allele producing red coat color (R) is incompletely dominant over the effect of the allele producing white coat color (r), the heterozygote being roan-colored (Rr). On the other hand, the effects of alleles for the absence of horns show complete dominance; HH and Hh are hornless or “polled”, and hh is horned. On the assumption that these two gene pairs assort independently: What would be the phenotype of an F1 derived from a mating RRHh X rrhh? What would be the phenotypes and their proportions in an F2 derived from the crossing F1 x F1? What would be the phenotypic proportions among the progeny derived from crossing F1 individuals to the original white horned stock?

4. In guinea pigs, one of the genes that affect coat color has a number of different alleles. In a certain strain of guinea pig, homozygous combinations of these alleles produce the following phenotypes: CC=black, cck=sepia, ccle=cream, caca=albino. Assuming that these alleles show complete dominance in the order given, CC-cck-cle-ca, what are the phenotypes and proportions that would expect among the offspring of the following crosses: Homozygous black x homozygous sepia, Homozygous black x homozygous cream, Homozygous black x homozygous albino, Homozygous sepia x homozygous cream? The F1 of cross #1 x the F1 of cross #3.

5. What phenotypes and ratios would you expect among the offspring of the following crosses: PP x ii, PP x Pi, Pi x Pi.

6. Alice became pregnant and isn’t sure of the father’s identity. Alice received marriage proposals from five men, but she has decided that only the true father of her child can have her hand in marriage. Alice’s blood type is B negative. Her five suitors have volunteered blood samples of their own: Henry O negative, Arthur A negative, William B negative, Schuyler A positive, Buddy AB positive. The child is born before Alice can make up her mind, and proves to be O positive. Which of the five men could have been the child’s father?

7. What is the chance that a man with type AB blood and a woman with type A blood whose mother is type O can produce a child that is
   a. type A
   b. type AB
   c. type O
   d. type B

8. A plant geneticist is examining the mode of inheritance of flower color in two closely related species of exotic plants. Analysis of one species has resulted in the identification of two pure-breeding lines: one produces a distinct red flower and the other produces no color at all; however, she cannot be sure. A cross of these varieties produces all pink flowered progeny. The second species exhibits similar pre-breeding varieties; that is, one variety produces red flowers, and the other produces albino flowers. A cross of the these two varieties, however, produces orange-flowered progeny exclusively. Analyze the mode of inheritance of flower color in these two plant species.

9. Mary Joy has Type A+ blood. Her mother was type B-. Daniel has Type O+ blood and his father had type A-.
   a. What is Mary Joy’s genotype?
   b. What is Daniel’s genotype?
   c. What is the expected phenotypic ratio among their children? Show your work with a Punnett Square.
10. Tay Sachs is a disease where enzymes that normally breakdown lipid in the cells that surround nerve cells is deficient, overwhelming the nerve cells with lipids. An affected infant begins to lose skills at about six months, then loses sight, hearing and the ability to move, typically dying within three years. People with Tay Sachs have two copies of the Tay Sachs allele. When parents of babies with Tays Sachs have their enzyme levels measured, they are half the normal reading compared to people in families with no Tay Sachs. Explain what could be happening at a genetic level.

Additional problems: See your textbook.
**AP Biology Genetics Problems Set 5:**

**Sex Linkage Genetics Problems**

1. Hemophilia A is caused by a sex-linked recessive gene in humans and dogs. What proportions and sexes among their offspring will be hemophiliacs if a hemophilic male is mated to a homozygous non-hemophilic female? If a daughter produced by the above mating is mated to a normal male, what proportions and sexes will be hemophilic among their offspring?

2. A common kind of red-green color blindness in humans is caused by the presence of a sex-linked recessive gene b, whose normal allele is B. Using these genes, what are all the possible colorblind genotypes and their corresponding phenotypes in males and in females?

3. Can a normal daughter have a colorblind father? A colorblind mother? Can a colorblind daughter have a normal father? A normal mother?

4. Can a colorblind brother and sister have another brother who is normal? Can a colorblind brother and sister have another sister who is normal?

5. A colorblind woman marries a normal-visioned man. They have two children, a boy and a girl. What will be the genotype and phenotype of the boy? What will be the genotype and phenotype of the girl?

6. A woman of A blood type and normal color vision produced five children as follows: 1. male, A blood type, colorblind, 2. male, O blood type, colorblind, 3. female, A blood type, colorblind. 4. female, B blood type, normal color vision. 5. female, A blood type, normal color vision. Of the two men that may have mated with this woman at different times, no. 1 had AB blood type and was colorblind, and no. 2 had A blood type with normal color vision. Which of these men is the most probable father in each case?

7. How many Barr bodies would the following individuals have?
   a. normal male
   b. normal female
   c. Klinefelter male
   d. Turner syndrome female
   e. Down syndrome female

Additional problems: See your textbook.
AP Biology Genetics Problems Set 6:
Autosomal Linkage Genetics Problems

1. A fully heterozygous F1 corn plant was red with normal seed. This plant was crossed with a green plant with tassel seed and the following results were obtained: red normal 124, red tassel 126, green normal 125, green tassel 123. Does this indicate linkage? Why or why not?

2. A fully heterozygous gray-bodied (G) normal winged(N) fruit fly crossed with a black-bodied(g) vestigial winged fly(n) gave the following results: gray normal 126, gray vestigial 24, black normal 26, black vestigial 124. Does this indicate linkage? If so, what is the percentage of crossing over? Diagram the chromosomes to show crossing over.

3. Alleles A,B,C are known to be linked. Allele A crosses over with B 10% of the time. Allele B crosses over C 20% of the time. Genes A and C cross over 10% of the time.
   a. What is the sequence of the genes on the chromosomes?
   b. What is the linear sequence and relative spacing of each allele on the chromosome?

4. Crossing over studies give the following percentages for the genes listed. Determine the gene sequence on the chromosome.
   yellow-veinless = 13.7%
   ruby-white = 6.0%
   ruby-veinless = 6.2%
   yellow-white = 1.5%
   white-veinless = 12.2%

5. Crossing over studies give the following percentages for the genes listed. Determine the gene sequence.
   a and b = 31%  x and y = 22%  x and b = 5%  a and x = 36%  a and y = 14%

6. Black body and dumpy wings are linked. Both traits are recessive. If a heterozygous wild type fly is back crossed with a black dumpy fly, what phenotypes are expected? If few wild dumpy and black wild flies are found how would you explain their presence?

Additional problems: See your textbook.
AP Biology Genetics Problems Set 7:
Genetics Problems to Illustrate A Few Concepts

1. **Polygenetic Inheritance:** The height of spike weed is a result of polygenic inheritance involving three genes, each of which can contribute an additional 5 cm to the base height of the plant, which is 10 cm. The tallest plant (AABBCC) can reach a height of 40 cm.
   
i. If a tall plant (AABBCC) is crossed with a base-height plant (aabbcc), what is the height of the F1 plants?
   
ii. How many phenotypic classes will there be in the F2?

2. **Epistasis:** In corn plants, a dominant allele I inhibits kernel color, while the recessive allele permits color when homozygous. At a different gene locus, the dominant allele P causes purple kernel color, while the homozygous recessive genotype pp causes red kernels. If corn plants heterozygous at both loci are crossed, what will be the phenotypic ratio of the offspring?

3. **Dihybrid Cross:** Two true-breeding varieties of garden peas are crossed. One parent had red, axial flowers and the other had white, terminal flowers. All F1 individuals had red, terminal flowers. If 100 F2 offspring were counted, how many of them would you expect to have red, axial flowers?

4. **Lethal Alleles:** A woman is a carrier for a sex-linked lethal allele that causes an embryo with the allele to spontaneously abort. She has nine children. How many of these children do you expect to be boys?

5. **Nondisjunction:** A female Tortoiseshell cat is heterozygous for the gene that determines black or orange coat color, which is located on the X chromosome. If a Tortoiseshell female cat mates with an orange male, what offspring would be expected? On a few rare occasions, a male tortoiseshell cat is born. Explain how this is possible.

(Human Disorders: Down’s Syndrome, Klinefelter’s syndrome Genetic Testing: Amniocentesis, CVS)

6. **Barr Bodies:** Women born with an extra X chromosome (XXX) are healthy and phenotypically indistinguishable from normal XX women. What is the likely explanation for this finding?

7. **Autosomal Linkage:** Assume that genes A and B are linked and are 50 ma units apart. An animal heterozygous at both loci is crossed with one that is homozygous recessive at both loci. What percentage of the offspring will show phenotypes resulting from crossovers? If you did not know that genes A and B were linked, how would you interpret the results from this cross?
Reading Pedigrees

Study each of the following pedigrees of families with certain hereditary traits. Determine whether each of the traits is dominant or recessive. Determine the genotype and phenotype of each individual in each pedigree. Record the genotypes and phenotypes on the pedigree.

Pedigree A: Deaf Mutism

One form of deafness in humans is a type in which the individual inherits not only deafness but also the inability to talk. Use symbols \( D \) for Dominant and \( d \) for recessive.

1. In pedigree A, why do parents 13 and 14 in generation III have four deaf children?

2. In pedigree A, how can parents 1 and 2 have a deaf child even though neither parent is deaf?

3. In pedigree A, why don’t parents 8 and 9 and 11 and 12 have at least one deaf child?

4. List by number the persons in pedigree A for which you cannot determine a genotype. Why can’t you determine the genotypes of these people?
Pedigree B: Hemophilia

Hemophilia is a disease of the circulatory system. It is sometimes called bleeder’s disease because persons with the disease have a very long clotting time when injured. An affected person could bleed to death from minor wounds or internal injuries. Use \( X^H \) for dominant and \( X^h \) for recessive.

5. In pedigree B, how can unaffected parents have an affected child?

6. What is the genotype of the mothers of all affected females in pedigree B? Explain.

7. What characteristic do all affected females in pedigree B have in common?

8. List by number the persons in pedigree B for which you cannot determine a genotype. Explain why a genotype cannot be determined.

Pedigree C: Brachydactyly

Brachydactyly is a condition in which fingers are abnormally short. The last two joints of the middle finger are shortened. In the other four fingers, the last two joints are fused into one and are also shortened. Use symbols \( B \) for dominant and \( b \) for recessive.

9. Is the brachydactyly trait in pedigree C dominant or recessive? Explain.
AP Biology Genetics Problems Set 8: Pedigree Practice Worksheet

1. Which members of the family above are afflicted with Huntington's Disease?

2. There are no carriers for Huntington's Disease- you either have it or you don't. With this in mind, is Huntington's disease caused by a dominant or recessive trait?

3. How many children did individuals I-1 and I-2 have?

4. How many girls did II-1 and II-2 have? How many have Huntington's Disease?

5. How are individuals III-2 and II-4 related? I-2 and III-5?

6. The pedigree to the right shows a family's pedigree for Hitchhiker's Thumb. Is this trait dominant or recessive? I

7. How do you know?

8. How are individuals III-1 and III-2 related?

9. How would you name the two individuals that have hitchhiker's thumb?

10. Name the two individuals that were carriers of hitchhiker's thumb.

11. Is it possible for individual IV-2 to be a carrier? Why?
12. The pedigree to the right shows a family’s pedigree for colorblindness. Which sex can be carriers of colorblindness and not have it? ________________

13. With this in mind, what kind of trait is colorblindness (use your notes)? ________________

14. Why does individual IV-7 have colorblindness?

15. Why do all the daughters in generation II carry the colorblind gene? ________________

16. Name 2 IV generation colorblind males. _____
Genetics Pedigree Worksheet

A pedigree is a chart of a person's ancestors that is used to analyze genetic inheritance of certain traits – especially diseases. The symbols used for a pedigree are:

- female, unaffected
- female, affected
- male, unaffected
- male, affected

- Siblings are placed in birth order from left to right and are labeled with numbers.
- Each generation is labeled with a Roman numeral.
  - Example: we would name an individual II-3 if he/she was in the second generation and the 3rd child born

Try to identify the genotypes of the following individuals using the pedigree above. (homozygous dominant, homozygous recessive, heterozygous)

- III-3: ______________
- II-1: ______________
- I-1: ______________
- II-4: ______________

1. Is this trait dominant or recessive? Explain your answer.

2. How can you know for sure that individuals II-3 and II-4 are heterozygous?

3. Brown eyes are a dominant eye-color allele and blue eyes are recessive. A brown-eyed woman whose father had blue eyes and whose mother had brown eyes marries a brown-eyed man whose parents are also brown-eyed. They have a son who is blue-eyed. Please draw a pedigree showing all four grandparents, the two parents, and the son. Indicate which individuals you are certain of their genotype and where there are more than one possibilities.
More Pedigree Practice

Family Trees called pedigrees are used to trace the inheritance of human genes. The two pedigrees below show the inheritance of sickle-cell disease, which is caused by an autosomal recessive allele. In the first pedigree, the square and circle symbols are colored, as far as genotypes are known. Fill in the genotypes — SS, Ss, and ss — below the symbols. Use question marks to denote unknown genotypes. Complete the second pedigree by coloring in the symbols, following pedigree rules. Again, denote unknowns with question marks.
AP Biology Genetics Problems Set 1:
Some Sample Genetics Problems for Your Test

1. A couple who are both carriers for the gene for cystic fibrosis have two children who have cystic fibrosis. What is the probability that their next child will have CF?

2. In a crossing a homozygous recessive with a heterozygote, what is the chance of getting a homozygous recessive phenotype in the F1 generation?

3. Black fur in mice (B) is dominant to Brown(b). Short Tails (t) is dominant to long (T). What proportion of the progeny of the cross BbTt x BBtt will have black fur and long tails?

4. Feather color in budgies is determined by two different genes that affect the pigmentation of the outer feather and its core. Y_B_ is green; yyB_ is blue; Y_bb is yellow and yybb is white. A green budgie is crossed to a blue budgie. Which of the following results is not possible?

5. A woman who belongs to blood group A and is Rh positive has a daughter who is O positive and a son who is B negative. What is a possible genotype for the son? for the mother? for the father?

6. Give parents AABBCc x AabbCc, assume simple dominance and independent assortment. What proportion of the progeny will be expected to phenotypically resemble the first parent?

7. What can one conclude from the fact that all seven of the garden pea traits studied by Mendel obeyed the principal of independent assortment?

8. Two true-breeding stocks of garden peas are crossed. One parent had red, axial flowers and the other had white, terminal flowers; all F1 individuals had red, axial flowers. If 1000 F2 offspring resulted from the cross, how many of them you you expect to have red, terminal flowers? (Assume no linkage)

9. A man and a woman, both normally pigmented, have an albino child together. The mother is now pregnant with fraternal (not identical) twins. What is the probability that both children will have normal pigmentation?

10. How many unique gametes could be produced through independent assortment by an individual with the genotype AaBbCCDdEE?

11. In cattle roan coat color occurs in the heterozygous offspring of red and white homozygotes. Choosing among roan, red and white cattle as possible parents, what cross could be made to produce the highest percentage of roan cattle? How could one produce a herd of pure-breeding roan-colored cattle?

12. Name a human genetic disorder that:
   - is recessive and can be overcome by regulating one’s diet
   - is dominant and appears around age 35-40
   - is recessive and is caused by a defective enzyme for the metabolism of gangliosides (lipids of the nervous system)
   - results from the “wrong” amino acid in the hemoglobin protein
   - is X-linked and prevents normal blood clotting

13. In birds, sex is determined by a ZW chromosome scheme. Males are ZZ and females are ZW. A lethal recessive allele that causes death of the embryo occurs on the Z chromosome in pigeons. What would be the sex ratio in the offspring of a cross between a male heterozygous for the lethal allele and a normal female?

14. When does independent assortment occur in Meiosis?

15. What kind of cells would normally contain a Barr body?
16. A recessive allele on the X chromosome is responsible for the red-green color blindness in humans. A normal vision woman whose father is color-blind marries a color-blind male. What is the probability that this couple's son will be color-blind?

17. To whom will a man with an X-allele pass it on to?

18. In cats, black color is caused by an X-linked allele; the other allele at this locus causes orange color. The heterozygote is tortoiseshell (calico). What kinds of offspring would you expect from a cross of a black female and an orange male? A few, rare calico male cats exist. How is this possible?

19. A achondroplastic dwarf man with normal vision marries a color-blind woman of normal height. The man's father was 6 feet tall and both the woman's parents were of average height. Achondroplastic dwarfism is autosomal dominant, and red-green color blindness is X-linked recessive. How many of their female children might be expected to be color-blind dwarfs?

20. If a pair of homologous chromosomes fail to separate during anaphase of meiosis I, what will be the chromosome number (N) of the four resulting gametes?

21. What is the order of genes on the chromosomes if these 4 genes cross over in the recombination frequencies indicated? Which of the four genes are are closest on the chromosome map?

b - cn 9%  b - rb 3.5%  b - vg 19%  cn - rb 6.5%  cn - vg 9%  rb - vg 16%

22. Genes A and B are linked at 12 map units between them. A heterozygous individual Ab/aB would be expected to produce gametes in what frequencies?

23. Vermilion eyes is sex-linked in fruit flies. If a female having vermilion eyes is crossed with a wild-type male, what proportion of the F1 males will have vermilion eyes?

24. The diploid number of honeybees is 32. What is the number of chromosomes in the somatic cells of a male honeybee? (Do you know how males are produced?)

25. What is a karyotype? What would a karyotype look like for:

- a normal male
- a normal female
- a Down's Syndrome male
- a Turner's syndrome female
- a Kleinfelter's syndrome male
ANSWERS TO SAMPLE GENETIC PROBLEMS.

1. 1/4
2. 1/2
3. (1) x (1/2) = 1/2
4. Incomplete Question
5. Son ABO rr mother AO Rr father BO? Rr
6. (1)(1)(3/4) = 3/4
7. That the 7 traits are found on 7 different chromosomes.
8. RR tt (3/4)(1/4) = 3/16
9. (3/4)(3/4) = 9/16
10. (2)(2)(1)(2)(1) = 8 different gametes
11. RED & WHITE => 100% ROAN ; impossible to produce a true-breeding population of Roan cattle

12. PKU
   - Huntington’s
   - Tay Sachs
   - Sicklecell anemia
   - Hemophilia

13. 2 male : 1 female \( \rightarrow \) males \( \frac{2}{3} \) \( \rightarrow \) females \( \frac{1}{3} \)

14. Metaphase I followed by Unequal female

15. Cells in females (except for gametes - eggs)

16. \( X^C X^c \) \( \times \) \( X^C Y \)
   50% of sons will be color-blind

17. He will pass it to all of his daughters, but none of his sons.

18. \( X^C X^c \) \( \times \) \( X^C Y \)
   Black \( \rightarrow \) \( \frac{1}{2} X^C X^c \) calico females
      \( \frac{1}{2} X^C Y \) Black males
   calico male caused nondisjunction

19. \( D d X^N Y \) \( \times \) \( dd X^n X^n \) \( \Rightarrow \) 0% would be colorblind dwarfs.

20. 2 will be \( N+1 \); 2 will be \( N-1 \)

21. \( b \) rb 6.5 cn 9 vg.
   Closest test

22. 44% \( A^b \); 44% \( a B^o \); 6% \( AB^o \); 6% \( ab \)

23. \( X^V X^v \) \( \times \) \( X^V Y \) \( \Rightarrow \) all \( X^V \) will be vermilion.

24. 16 (6\(^{\circ}\) are haploid).

25. Karyotype is a
   picture of a person's chromosomes.
   \( 46 \) chromosomes, \( X \)
   \( 47 \) chromosome, \( 3 \) \( X \) \& \( Y \)
   \( 45 \) chromosome, \( 1 \) \( Y \) \& \( X \)
   \( 47 \) chromosome, 3 \( X \) \& \( X \)
AP Biology Review for Final Exam first Semester

Major Topics Include:

1. Chemistry: Atomic structure, Isotopes, Types of Bonds, Electronegativity
2. Properties of water and how they apply to living organisms
3. Properties of Carbon that make it impt. as the base of organic molecules
4. Structure and Function of Organic molecules:
5. Proteins, Carbohydrates, Lipids, Nucleic Acids
7. Transport of water and food in plants; application of Water & Membranes to this transport
8. Enzymes: Structure, Induced Fit, Activation Energy, Regulation & Control
9. Cells: Structure and Function of cell parts including but not limited to: Plasma membrane, Nucleus, Nucleolus, Chromosomes, Ribosomes, Rough and Smooth, Endoplasmic Reticulum, Golgi Apparatus, Lysosomes, Vacuoles (special types), Mitochondrion, Chloroplast, Microtubules, Microfilaments, Cilia, Flagella, Cell Walls; Compare plant with animal cells
10. Structure of Cell Membranes (Fluid Mosaic Model)
11. Movement across membranes (Permeability, Diffusion, Osmosis, Water Potential, Active Transport, Endocytosis and Exocytosis)
12. Aerobic Respiration: Oxidation/ reduction reactions, Major purposes, starting materials, ending products, energy changes of Glycolysis, Krebs Cycle and Electron Transport Chains, Chemiosmosis
13. Fermentation: Alcoholic and Lactic Acid Fermentation
14. Photosynthesis: Structure of Leaves, Characteristics of Light, Absorption Spectrum of Chlorophyll, Light Reactions (Non-cyclic and cyclic electron flow), Dark Reactions, C3, C4 and CAM plants, Photorespiration
15. Cell to cell communication
16. Mitosis: Steps of Prophase, Metaphase, Anaphase, Telophase and Interphase; Cytokinesis, Cell Cycle
17. Meiosis: Chromosome numbers, Homologous Chromosomes, Steps of Meiosis I and Meiosis II, Compare meiosis with mitosis, Life cycles of plants and animals, Independent Assortment, Crossing over, Fertilization, Nondisjunction
18. Genetics: Mendel's Laws, Monohybrid cross, Dihybrid crosses, Codominance, Multiple alleles, autosomal linkage, X-Linkage, Sex determination, Linkage maps, Crossing over frequencies, Pedigree analysis, Various Human disorders
19. Organismal Biology in these areas: Digestive systems, Respiratory Systems, Endocrine Systems, and Reproductive & Developmental Systems
AP LABS

A. #4: Osmosis and Diffusion
B. #13: Enzyme Catalysis
C. #7: Mitosis and Meiosis, Chi-square analysis
D. #5: Plant Pigments and Rates of Photosynthesis
E. #4: Cell Respiration (Peas)
F. #11 Transpiration, Leaf Anatomy, & Stomate Densities
G. Scientific Methods: Science Practices
H. Microscopes & Cell Structures
I. Lung Volumes & Breathing Rates
J. Genetics of Drosophila, Chi-Square

SECTION I: Multiple Choice

There will be about 60 multiple choice questions and four grid-in mathematically based questions.

SECTION II: Essays

There will be one long essay and 3 short essays.