****Genetics Practice Problems****

Class Copy

Use Punnett Square to answer the following questions.
Show your work following the Punnet Practice rules.

PART A: BASIC GENETICS

1. Widow's peak is dominant to no widow's peak. Determine the genotype and phenotype ratios for a cross between a homozygous dominant female and a homozygous recessive male.

2. Dimples is dominant to no dimples. Determine the genotype and phenotype ratios for a cross between a heterozygous female and a homozygous dominant male.

3. Short hair is dominant to long hair in mice. Determine the genotype and phenotype ratios for a cross between a homozygous recessive female and a heterozygous male.

4. Cleft chin is dominant to no cleft chin. Determine the genotype and phenotype ratios for a cross between a heterozygous female and a heterozygous male.

5. Brown eyes are dominant to blue eyes. Determine the genotype and phenotype ratios for a cross between a homozygous dominant female and a homozygous dominant male.

6. Purple flowers are dominant to white flowers in pea plants. Determine the genotype and phenotype ratios for a cross between a homozygous dominant female and a heterozygous male.

7. Brown hair is dominant to gray hair in mice. Determine the genotype and phenotype ratios for a cross between a homozygous recessive female and a homozygous recessive male.

8. Free ear lobes are dominant to attached ear lobes. Determine the genotype and phenotype ratios for a cross between a heterozygous female and a homozygous recessive male.

9. Green peas are dominant to yellow peas. Determine the genotype and phenotype ratios for a cross between a heterozygous female and a heterozygous male.

10. Tall plants are dominant to short plants. Determine the genotype and phenotype ratios for a cross between an homozygous recessive female and a homozygous dominant male.

11. In a certain species of mouse, pointed ears are dominant over round ears. Predict the genotypes and phenotypes of a cross between two hybrid (=heterozygous) pointed-eared mice.

12. In a certain species of dog, a black nose is dominant over a pink nose. Predict the genotypes and phenotypes of a cross between a purebred dominant male dog and a purebred recessive female.

13. A heterozygous round seeded plant is crossed with a homozygous round seeded plant. Predict the genotypes and phenotypes of the cross.

14. In pea plants purple flowers are dominant to white flowers. Predict the genotypes and phenotypes of a cross between two white flowered plants.

15. In guinea pigs, the allele for short hair is dominant. Show the cross for a pure breeding short haired guinea pig and a long haired guinea pig.

16. In Drosophila flies, antennapedia (an extra pair of legs where antennae should be) is caused by a dominant allele A at a single genetic locus. Consider a mating between two heterozygous flies. Describe the expected genotypic ratio and the expected phenotypic ratio of their offspring.

17. Cystic fibrosis of the pancreas is an inherited condition caused by faulty metabolism of fats. Affected individuals are homozygous recessive for the responsible allele and often die in childhood. If a heterozygous man marries a heterozygous woman, what is the probability that their first child has the disease? What is the probability that the first child does not have the disease?

18. In cats, brown coat color is a single gene trait caused by a dominant allele. Homozygous recessive cats are white. If a brown female bears a litter of kittens some of which are white, what is her genotype?

PART B: Co- and Incomplete Dominance

1. Hair texture in humans is controlled by one gene that has two alleles – curly and straight. A curly-haired woman and a straight-haired man have five children. All of them have wavy hair – somewhere in between straight and curly. Make a Punnett square to show a cross between the parents in the example listed above. Give the expected genotypic and phenotypic outcomes of this cross.

2. A wavy-haired man marries a curly-haired woman. Make a Punnett square to show the cross between these two people. Give the expected genotypic and phenotypic outcomes of this cross.

3. In petunias, there is a gene that controls flower color. There are two alleles – purple and white. A purple petunia that is crossed with a white petunia will produce a plant with flowers that are striped purple and white like the picture to the right. Show a cross between a plant that is purple and a striped plant. Give the expected genotypic and phenotypic outcomes of this cross.

4. There are three alleles that control the ABO blood type, IA, IB, and i. A person only carries two at a time (one from each parent). Show a cross between a man with I^Ai and I^Bi. Give the expected genotypic and phenotypic outcomes of this cross.

5. Dr. Paul is blood type O. His father was blood type A and his mother was blood type B. What were the genotypes of his parents and what are the possible blood types and ratios expected for crosses involving Dr. Paul's parent's genotypes?

6. A snapdragon pure breeding for red flowers is bred with one for white flowers. The F1 generation flowers are all pink. What would you predict for the phenotypic ratios for the F2 generation?

7. A white cow was mated with a red bull producing a roan calf. Close inspection of the calf revealed its roan color is caused by a mixture of red and white hairs. What is the calf's genotype?

8. A woman with type A blood has a child with type O blood. She is suing a man with type B blood for child support, because she claims that man is the father of her child. How would you respond to the following statements:
    a. The attorney for the alleged father claims "The mother's blood is type A, so the child's type O blood must have come from the father. Because my client has type B blood, he can not be the father."
    b. The attorney for the mother claims "Because further tests prove he is heterozygous, he must be the father."

9. A child has type A blood. What are ALL the possible blood types of its parents? Show each cross to prove that it is possible.

10. In four-o'clock flowers, red flower color (R) is incompletely dominant over white (r), and heterozygous plants (Rr) have pink flowers. What gametes will be produced by each parent in the following crosses, and what will be the phenotypes of the offspring?
    a. Rr X RR
    b. rr X Rr
    c. RR X rr
    d. Rr X Rr

11. In snapdragons, red flower color (R) is incompletely dominant to white (r), with heterozygous plants being pink. The broad-leaf allele (B) is incompletely dominant over narrow leaves (b), with the heterozygous plants having medium-width leaves. If a red-flowered, broad-leaved plant is crossed with a white-flowered, narrow leaved one, what will be the appearance of the F1 and F2 plants?

12. In a paternity suit, where a woman claims that a particular man is the father of her child, the blood types of the three individuals are often tested to see if her claim could be correct. In each of the following cases, determine whether it is possible that the male is the father of the child:
    a. Mother is type A, child is type B, alleged father is type A
    b. Mother is type A, child is type A, alleged father is type B
    c. Mother is type O, child is type O, alleged father is type A

13. If one parent is type A and the other is type B, but all four blood types are represented among the children, what were the genotypes of the parents?

PART C: Sex Linked Genes

1. Hemophilia is a recessive sex-linked trait caused by a defective gene. The normal allele produces a protein called Factor VIII that allows blood to clot. Without injections of synthetic Factor VIII, hemophiliacs are at risk of dying due to excessive bleeding. Make a Punnett square to show a cross between a normal male and a female who is heterozygous. Give the expected genotypic and phenotypic outcomes for this cross.

2. Red-green colorblindness is also a recessive sex-linked trait. Make a Punnett square to show a cross between a colorblind male and a homozygous normal female. Give the expected genotypic and phenotypic outcomes of this cross.

3. Nystamus is a condition in humans characterized by involuntary rolling of the eyeballs. The allele for this condition is incompletely dominant and sex-linked. Three phenotypes are possible: Normal, slight rolling, severe rolling. A woman who exhibits slight nystagmus and a normal man are considering marriage and ask a geneticist what the chance is that their children will be affected. What will counselor tell them?

4. Hemophilia in humans is inherited as an X linked recessive trait. A woman whose father is hemophiliac marries a man with normal clotting ability. What is the probability that her first child will have hemophilia? Assume that the woman's mother is homozygous dominant.

5. Suppose expression of one allele of a Y-linked gene results in non-hairy ears in males. Expression of another allele results in rather long hairs, a condition known as hairy pinnae.
    a. Why would you NOT expect females to have hairy pinnae?
    b. A son of a hairy-eared male will also be hairy-eared. Explain why.

6. Calico is a coat color found on cats, which is caused by a SEX-Linked, CODOMINANT allele. B= black, R = orange, BR = calico. Show each of the crosses below. Include the phenotypic ratios.

Female cats can be black $X^B X^B$, orange $X^R X^R$ or calico $X^B X^R$ Male cats may only be black $X^B Y$ or orange $X^R Y$

   a. A black male crossed with an orange female.
   b. A orange male crossed with a calico female.
   c. A black male crossed with a black female
   d. A orange male crossed with a orange female
   e. A black male crossed with a calico female

PART D: Dihybrid Crosses

1. Practice Problem: In peas, a gene for tall plants is dominant over its allele for short plants. The gene for smooth peas is dominant over its allele for wrinkled peas. Determine phenotypes, genotypes and offspring ratios for each of the following crosses (T = tall, t = short, S = smooth, s = wrinkled). Show the Punnett square for each problem, and list the ratio obtained.
   A. Tt Ss x Tt Ss
   B. Tt ss x tt ss
   C. Tt Ss x Tt ss
   D. TT ss x tt SS

2. In about 85% of humans (called "secretors"), the A or B blood type protein is found in saliva and other body fluids as well as in the blood. The other 15% do not have blood type proteins in the saliva ("nonsecretors"). If secretor (S) is dominant to non-secretor (s) and this gene assorts independently of the A-B-O blood type gene, what proportion of the offspring from a mating between type AB, Ss with type AB, Ss would have A, B or both blood type proteins in their saliva?

PART E: Beyond Dihybrid

1. You are heterozygous for freckles (Ff), heterozygous for dimples (Dd), and are heterozygous for a widow's peak (Ww). Your significant other is also heterozygous for freckles (Ff) and dimples (Dd), but has a continuous hairline (ww). In other words,

You		**Your S.O.**
FfDdWw	x	FfDdww

   What is the chance your darling child would have all three recessive phenotypes: no freckles (ff), no dimples (dd) or a continuous hairline (ww)?

2. In the following cross, what is the probability of obtaining offspring that show all three dominant traits, A_B_C_ (_ indicates that the second allele can be either dominant or recessive without affecting the phenotype determined by the first dominant allele)?
   a. AaBbcc x AabbCC

   b. Probability of offspring that are A_B_C_= _____

3. For the following crosses, determine the probability of obtaining the indicated genotype in an offspring:

4. Cross	**5. Offspring**
6. AAbb X AaBb	7. AAbb
8. AaBB X AaBb	9. aaBB
10. AABbcc X aabbCC	11. AaBbCc
12. AaBbCc X AaBbcc	13. aabbcc

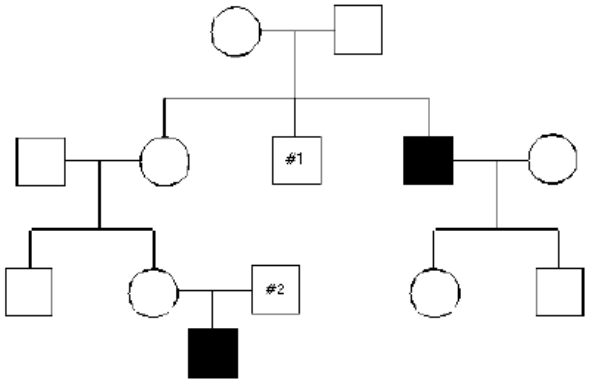
14. In humans, two abnormal conditions, cataracts in the eyes and excessive fragility in the bones, seem to depend on separate **dominant** genes located on different chromosomes. A man with cataracts and normal bones, whose father had normal eyes, married a woman free from cataracts but with fragile bones. Her father had normal bones. What is the probability that their first child will:
    a. Be free from both abnormalities;
    b. Have cataracts but no fragile bones;
    c. Have fragile bones but not cataracts;
    d. Have both cataracts and fragile bones?

15. A pure-breeding plant with red flowers, yellow seeds, square stems, and serrated leaves with white veins is crossed with a pure-breeding plant having white flowers, pink seeds, round stems and smooth-edged leaves with green veins. All the offspring have red flowers, pink seeds, square stems, and serrated leaves with yellow veins. If these offspring are crossed with each other and 1000 F2 plants are obtained, how many of the offspring should have yellow seeds? How many of the offspring should have yellow veins?

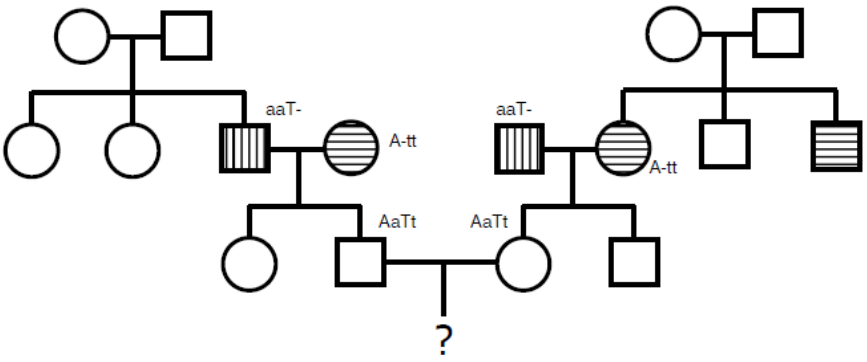
16. In humans there are three alleles at the *ABO* locus causing blood types A, B, AB, O. How many genotypic and phenotypic combinations are possible in the offspring of a brown-eyed, red-haired, taster man with AB blood group (*Bb rr Tt AB*) married to a blue-eyed, non-red haired, taster with type A blood (*bb Rr Tt AO*) woman?

PART F: Pedigrees

1. For the traits shown in the following human pedigree, state whether the most likely mode of inheritance is dominant or recessive. Base your decision only on the information given, and briefly state your evidence. If there's not enough information to decide between the two possibilities, say so. Then give the genotype for the two numbered individuals in the pedigree.

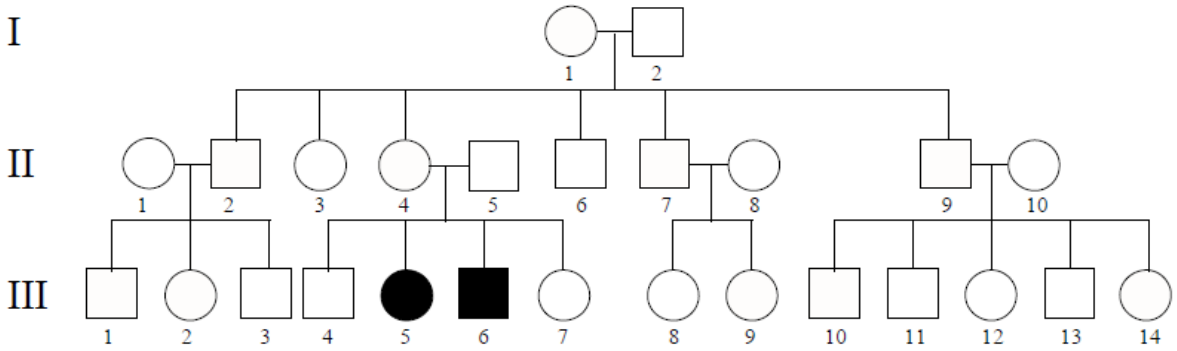


2. The following pedigree shows the inheritance of two human genetic disorders. Symbols with vertical stripes indicate individuals who have alkaptonuria (an inherited metabolic disorder), and symbols with horizontal stripes indicate individuals who have tyrosinemia (an inherited enzyme deficiency).
    a. Based on the information here, is alkaptonuria a dominant trait or a recessive trait? Give specific evidence to justify your conclusion.
    b. Based on the information here, is tyrosinemia a dominant trait or a recessive trait? Give specific evidence to justify your conclusion.
    c. What is the chance that the couple at the bottom of the pedigree will have a child (indicated by the question mark) who has both alkaptonuria and tyrosinemia?



3. Suppose you decide to investigate the genetics of leg-crossing. You interview your maternal grandparents, your mother and father, your mother's two brothers and your sister. Your mother is the only one in the family who prefers right over left; everyone else prefers left over right.
    a. Draw the leg-crossing pedigree for the family.
    b. Explain how leg-crossing is inherited, giving evidence from the pedigree.
    c. Show the genotypes of your family members on the pedigree

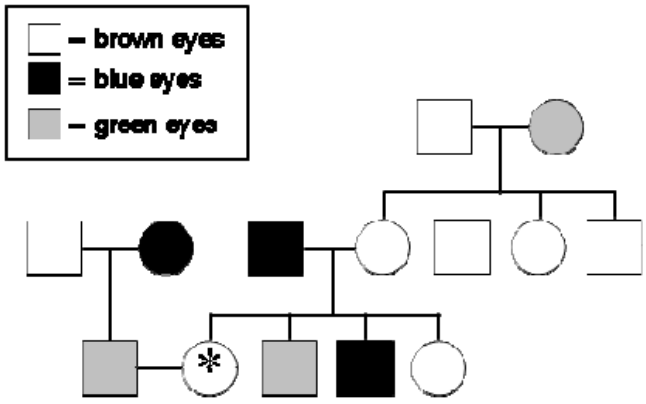
4. A pedigree for Gaucher disease, a human genetic disorder resulting in anemia and problems with liver and spleen function, is shown below. What is the genotype of each of the following individuals: II-4, II-5, and I-2



5. Human eye color is actually much more complicated than the simple brown-dominant-over-blue model you may have seen before. Eye color can be partly explained by looking at two different genes, *bey* and *gey*. There are two alleles of the *bey* gene, brown (*B*) and blue (*b*), and brown is completely dominant over blue. There are also two alleles of the *gey* gene, green (*G*) and blue (*g*). The green allele is completely dominant over the blue *gey* allele. However, the two genes interact as follows: (1) if there is at least one brown *bey* allele, eyes will be brown even if there is a green *gey* allele, and (2) if there is at least one green *gey* allele, eyes will be green as long as there's no brown *bey* allele.

    a. What is the probability that the woman marked with the asterisk (*) has the genotype *BbGg*?

    b. If this is actually her genotype, what is the probability that she'll have a green-eyed child?



PART G: Epigenics

1. In mice, coat color is determined by a gene, *B*, which has black and brown alleles. Black is completely dominant over brown. However, there is a second gene, *C*, which also affects color. Mice must have at least one dominant allele of this gene in order to show any color (black or brown); if they do not, they're white. A pure-breeding brown mouse is crossed with a mouse that is homozygous recessive for both genes. What are the genotypes and phenotypes of these two parents? What are the genotypes and phenotypes of their F1 offspring? If two of the F1 mice are crossed, what will be the phenotypes of their offspring, and in what proportions?

2. One set of coat color alleles in guinea pigs is multiple allelic. When homozygous the phenotypes are: *CC,* black; c^kc^k, sepia; c^dc^d, cream; c^ac^a, albino. The observed dominance relationships are: *C* is dominant to all other alleles, c^k is dominant to c^d and c^a, c^d is dominant to c^a. What phenotypic ratios are expected when Cc^k males are mated with c^dc^a females?

3. In gerbils, fur color is controlled by two different genes. One gene determines how much black pigment is produced; there are two alleles, producing black and tan colors. These two alleles show incomplete dominance, and heterozygotes are brown. A second gene determines whether any pigment (of any color) is produced: at least one dominant allele of this gene is required in order for gerbils to be black, brown or tan; otherwise, they are white. This second gene is sex-linked.

   a) What would be the most appropriate symbols to use for the two alleles of the first gene (controlling black, brown and tan colors)?
   b) What would be the most appropriate symbols to use for the two alleles of the second gene (controlling whether any pigment is made)?
   c) What would be the genotype of a black male gerbil?
   d) What would be the genotype of a white female gerbil that had one black parent and one tan parent?
   e) If these two gerbils are mated, what genotypes will you expect among their offspring, and in what proportions?
   f) What phenotypes will you expect, and in what proportions?

4. In mice, the dominant allele of gene A produces black fur, while the recessive allele produces brown fur. However, there is a second gene, B, that also affects fur color. A recessive allele of this gene produces a defective enzyme, and if there is no functional "B" enzyme, the mice will be white no matter what alleles they have for gene A.
   a) What will be the phenotypes of a male mouse with genotype AAbb and a female mouse with genotype aaBB?
   b) What will be the genotypes and phenotypes of their F1 offspring?
   c) What will be the genotypes and phenotypes of the F2 generation produced from a cross of two of the F1 mice?

5. Retinitis pigmentosa, a form of blindness in man may be caused either by a dominant autosomal gene, R, or a recessive autosomal gene, a. Thus only A_rr individuals are normal. An afflicted man whose parents are both normal marries a woman of genotype AaRr. What proportion of the children are expected to suffer from this affliction if R and A are inherited independently?

6. Horses can be bay in color. This dominant gene allele (A) masks the dominant black color (B), but not the white gene (W_) or the recessive chestnut color (ww). What is the phenotype and genotype of the offspring when a bay mare (AaBBww) is crossed with a bay stallion (AaBbww)?

7. Horses also carry a dilution gene (D). If only one allele is the dominant D, and a dominant A allele and the recessive chestnut color genes are present, then the horse will be a palamino. If there are two dominant dilution alleles (DD) and all else is the same as previously mentioned, the horse will be a pseudo albino. What is the phenotype and genotype of the offspring when a palomino mare (AAbbDdww) is crossed with a palomino stallion (AabbDdww)?

8. The color of the flower center in the common yellow daisy may be either purple centered or yellow centered. Two genes P and Y are known to interact in this trait.
   P_Y_ purple centered
   ppY_ yellow centered
   P_yy yellow centered
   ppyy yellow centered
   What are the geneotypes and phenotypes for the following cross: PpYy x PpYy

9. In Labrador Retrievers the B allele confers black coat color and the b allele brown coat color. The E gene controls expression of the B gene. If a dog inherits the E allele the coat is golden no matter what the B genotype is. A dog of genotype ee expresses the B(black) genotype.
   B_E_ Black
   bbE_ Chocolate
   B_ee Yellow
   bbee Yellow
   Using the genotypes above predict the phenotypic ratio if a female Bbee is bred to a male bbEe?

10. Red color in wheat kernels is produced by the genotype R_B_. White is produced by the double recessive rrbb. The genotypes R_BB and rrB_ produces brown kernels. If a red kernel wheat plant with the genotype RrBb is fertilized by a brown wheat plant rrBb, what type of wheat plants are produced?

11. White fruit color in summer squash is governed by a dominant gene (W) and colored fruit by its recessive allele(w). Yellow fruit is governed by a dominant gene G. The color green is determined by the genotype g.
    W_G_ white
    W_gg white
    wwG_ yellow
    wwgg green

    What would result if the white squash, Wwgg is cross pollinated to a wwGg? What color squash would result?

12. Fur color in rabbits is determined by a single gene loci for which there are <u>four alleles</u> (B, B^{ch}, B^{h} and b). Four phenotypes are possible: black, chinchilla (gray color caused by white hairs with black tips), Himalayan (white with black patches on extremities), and white. The black allele (B) is dominant over all other alleles, the chinchilla allele (B^{ch}) is dominant over Himalayan (B^{h}), and the white allele b is recessive to all others. A black rabbit is crossed with a Himalayan and the F_1 consists of a ratio of 2 black to 2 Chinchilla. Can you determine the genotypes of the parents?

PART H: More Complex

1. The height of spike weed is a result of polygenic inheritance involving three genes (A, B and C), each of which has 2 alleles. Each dominant allele can contribute an additional 5 cm to the base height of the plant. The base height of the weed is 10 cm (aabbcc), and the tallest plant can reach 40cm (AABBCC).
   a. If a tall plant (AABBCC) is crossed with a base-height plant (aabbcc), what is the height of the F_1 plants?
   b. How many phenotypic classes will there be in the F_2?

PART I: Linked Genees

1. In guinea pigs, black (B) is dominant to brown (b) and solid color (S) is dominant to spotted (s). A heterozygous black, solid-colored pig mated with a brown, spotted pig. The total offspring for several litters are black solid = 16, black spotted = 5, brown solid = 5, and brown spotted = 14. Are these genes linked or non-linked?

2. From a cross between individual with genotypes CcDdEe x ccddee, 1000 offspring were produced. The class appearing C_D_ee totaled 351 individuals. Are the genes c,d and e on the same or different chromosome pairs? How do you know?

3. A cross AABB x aabb results in an F1 of phenotype AB; The following numbers are obtained in the F2 (Phenotypes):

A_B_	284
A_bb	21
aaB_	24
aabb	55
Total	381

   a. What F2 numbers would be expected?
   b. Are genes at the a and b loci linked or independent?

4. In corn the F1 from pure breeding parents (AABB x aabb) is test-crossed. The distribution of the phenotypes was as follows.
   A_B_ 122
   A_bb 118
   aaB_ 81
   aabb 79

   Are the genes assorting independently? Explain your answer.

5. The F1 from a cross of AABB x aabb is test-crossed, resulting in the following phenotypic ratios.
   A_B_ 308
   A_bb 190
   aaB_ 210
   aabb 292

   Identify the recombinants.

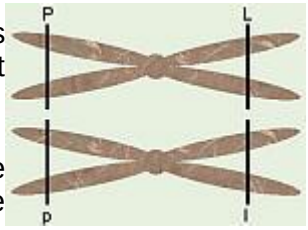
6. In the high-pressure, deep, dark depths of the ocean's abyssal plains lives an organism called a viper fish. These fish resemble transparent eels with overlarge heads and very long, pointy teeth. Because of where they live, very little is known about these fish but for the sake of this problem, we shall assume that some of them can produce biochemical lights along the length of their bodies and some cannot. Also, some have very large eyes while some have almost no eye at all. Further, we shall assume that these two traits are each controlled by single locus genes with the production of lights (L) and large eyes (E) being the dominant alleles for each. Lastly, assume that these genes are linked. It is very difficult in the vast expanses of the deep ocean for two viper fish to find each other, but suppose that a female heterozygous for both traits (the two dominant alleles are on one chromosome and the two recessive are on its homolog in this individual) happens to meet a male that is homozygous dominant for lights and homozygous recessive for eyes. Using the rules for Reginald Punnett Pleasure and correct notation, what are the possible genotypes and phenotypes of their offspring?

7. Snow leopards live in the high reaches of the Himalayas and have several adaptations to deal with living most of the time in snow. They have wide paws with hair between the toes to allow them to run on top of the snow crust. Assume that wide paws (W) and hair between the toes (T) are both dominant traits and are on the same chromosome. Suppose that two snow leopards, heterozygous for both traits, mate. Suppose further that in the female, the two dominant alleles are on the same chromosome of the homologous pair, while in the male, each chromosome of the pair has one dominant and one recessive allele. Using the rules for Reginald Punnett Pleasure and correct notation, what are the possible genotypes and phenotypes of their offspring?

8. Suppose you have a bunch of white mice, some that are only white and some with black spots. There are also some of your mice with black eyes and some with pink eyes. Assume that the genes for hair color and eye color are linked and that plain white (W) is dominant to black spots and that black eyes (B) are dominant to pink. You decide to cross a female that is homozygous dominant for hair color (you just happen to know the genotype of each mouse) and heterozygous for eye color with a male that is heterozygous for both traits. In the male, each homologous chromosome contains a dominant and recessive allele from the two genes. Using the rules for Reginald Punnett Pleasure and correct notation, what are the possible genotypes and phenotypes of their offspring?

9. A group of spiders known as orb weavers often construct patterns with threads visible in the ultraviolet spectrum into the centers of their webs. These patterns mimic the centers of flowers and provide a lure for unwary flying insects that can see in the ultraviolet range. Suppose that in a particular species of orb weavers, the gene controlling the type of pattern placed in the center of the web is linked to a gene controlling whether the spider has green spots. In this case, the allele for a solid circle (P) of UV pattern is dominant to the allele for concentric rings forming a target pattern and the allele for green spots (G) is dominant to no spots. Suppose a female heterozygous for both traits and with the dominant alleles of the two traits on one homologous chromosome and the recessive alleles on the other homolog mates with a male that is homozygous recessive for pattern type and heterozygous for spots. Using the rules for Reginald Punnett Pleasure and correct notation, what are the possible genotypes and phenotypes of their offspring?

10. The genes for pollen shape and flower color are located on the same chromosome as each other, thus are inherited together. Purple (P) and long pollen (L) are dominant to red (p) and round pollen (l).



    a. Using the rules for Reginald Punnett Pleasure and correct notation, what are the possible genotypes and phenotypes of the offspring if the parents are PPLL × ppll?
    b. Using the rules for Reginald Punnett Pleasure and correct notation, calculate the genotypes and phenotypes in the F2 generation.