## BASIC GENETICS

1. State the principle of segregation. From what you know about meiosis, how does segregation take place?
2. State the principle of independent assortment. Will the height of a pea plant affect the color of the plant's flowers? Why or why not?
3. List some human traits that you think exhibit independent assortment.
4. Is it possible to be heterozygous for a characteristic and express the recessive phenotype? Explain.

## Genetics: Monohybrid (one trait) Mendelian Crosses

Instructions: in all problems below, use a Punnett square to predict the outcome. Please show both the phenotype and genotype ratio.

1. In peas, the gene for tall (T) is dominant to the gene for short (t). What will happen if a plant that is homozygous tall is crossed with a plant that is heterozygous tall?
2. In carnations, the gene for red flowers (R) is dominant to the gene for white flowers (r). What will happen if a plant homozygous for red flowers is crossed with a plant homozygous for white flowers?
3. In mice, the gene for a black coat (B) is dominant to the gene for a white coat (b). What will happen if a mouse that is heterozygous black is crossed with a mouse that is homozygous white?
4. Why does an organism that shows a recessive phenotype have to be homozygous?
5. Reread the information on carnations in question 2. What will happen if two plants that are heterozygous red are crossed with one another?
6. In humans, the genetic disease sickle cell anemia is caused by a recessive allele (s). The normal allele (S) codes for normal hemoglobin, the oxygen carrying protein in red blood cells. A man with sickle cell disease has children with a woman who is heterozygous normal. What is the probability that their children will inherit the disease? What is the probablility that their children will be carriers?
7. Once more, we return to carnations (see question 2). Say that you have a red carnation plant. You don't know if it's homozygous or heterozygous. How could you figure this out? Demonstrate your answer by setting up a Punnett square.
8. In summer squash, white fruit color is dominant. Yellow is recessive. A squash plant that is homozygous for white is crossed with a homozygous yellow one. Predict the appearance of: (a) the $F_1$ generation; (b) the $F_2$; and (c) the offspring of a cross between an $F_1$ individual and a homozygous white individual.
9. The houseplant coleus has curves on the edge of its leaves. Deep curves (D) are dominant over shallow curves (d). Draw a Punnett square showing the possible offspring of a cross between a homozygous plant with deep curved leaves and a plant with shallow curved leaves. What are the possible phenotypes of the offspring?
10. In tomato plants, long veins (L) are dominant over short vines (l). The incomplete Punnet square below shows a cross between two tomato plants:

| | | |
|---|---|---|
| | LL | LL |
| | Ll | Ll |

->Complete the Punnett square by filling in the **gametes** of both of the parents. Identify the phenotypes of the parents and the offspring.

11. In a hybrid cross between homozygous dominant and homozygous recessive parents, there are 32 offspring in the F2 generation. According to the Mendelian ratio, what number of the offspring should show the recessive trait. What number should show the dominant trait.

12. You just bought 47 plants from a plant nursery that are all from the same parents. All of the plants have Blue flowers, but you know that the this species of plant also has white flowers sometimes. Blue flowers are dominant (B) over White flowers (b). Explain how you might determine if your plants are homozygous for the blue gene or heterozygous for the blue gene.

## Genetics: Dihybrid (two trait) Crosses

Instructions: in all problems below (except 1-3 ) use a Punnett square to answer the question.

**1-4 are based on the following: In peas, round seeds (R) dominates over wrinkled seeds (r). Yellow seed color (Y) dominates over green (y).**

1. What is the genotype of an organism that is homozygous round and heterozygous yellow? What gametes could this organism form?
2. What is the genotypes of an organism that is heterozygous round and homozygous green? What gametes could it form?
3. What is the genotype of an organism whose genotype is homozygous wrinkled and homozygous yellow? What would be the possible genotypes of its gametes?
4. Cross a homozygous round, heterozygous yellow plant with one that is heterozygous round and homozygous green. What are the phenotypes of the offspring?

**5 and 6 are based on the following: In watermelon, green (G) is dominant to striped (g). Short (S) is dominant to long (s).**

5. What is the genotype of an organism that is heterozygous green and heterozygous short?
6. Cross two individuals who ar both heterozygous green and short. What are the phenotypes of the offspring?

**7 and 8 are based on the following: In humans, the gene for normal skin color (A) dominates the gene for albino skin (a). The gene for normal body height (M) dominates the gene for being a midget (m).**

7. Cross one parent that is heterozygous normal skin and heterozygous normal height with a heterozygous normal skin midget. What are the resulting phenotypes?
8. Cross a homozygous normal skinned midget with an albino midget. What are the resulting phenotypes?
9. In dogs, short hair is dominant over long and dark hair is dominant over light. One dog is heterozygous for hair length and shows the recessive trait for hair color. Another dog is homozygous dominant for hair length and heterozygous for hair color. Construct a Punnett square showing the dihybrid cross between these two dogs. Identify the phenotypes that might result.
10. In guinea pigs, a black coat is dominant over a white coat. Can two white-coated parents produce an offspring with a black coat? Why or why not?

## BLOOD TYPE

1. Explain why type O blood is sometimes referred to as the universal donor. Is this true in the case of O+ blood ?
2. A woman with type A blood has a baby with type O blood.
    a. What is the mother's blood type?
    b. Could a man with type B blood be the father?
    c. List the man's possible genotypes.

3. Why is a person with type AB blood considered a universal recipient?
4. What are the possible genotypes that could produce blood type A.
5. What is the probable genotypic ratio among children born to a mother having the genotype IAi and a father with blood type AB?
6. One parent has type A blood and the other parent has type B blood. What are their genotypes if they produce a large number of children whose blood types are:
    a) all AB
    b) 1/2 AB and 1/2 B,
    c) 1/2 AB and 1/2 A, and
    d) 1/4 AB, 1/4 B, 1/4 A, and 1/4 O?
7. Three brothers have blood types A, B, and O. What are the chances that the parents of these three will have a fourth child whose blood type is AB?

8. A man with blood type AB marries a woman with blood type O. Is it possible for them to have children with the same blood type as either of the parents? Use a Punnett square to explain your answer.

9. An abandoned baby was picked up by the police. Later two different women claimed to be the mother. Blood studies revealed that woman 1 was type A. Woman 2 was type AB. The baby was type O. Which woman was possibly the mother? Explain.

10. What are the possible blood types of children in the following families?
    a. Type A mother, Type A father
    b. Type A mother, Type O father
    c. Type B mother, Type AB father
    d. Type AB mother, Type AB father
    e. Type A mother, Type B father

11. A man with blood type B marries a woman with blood type A. Their first child has type O blood. What are the genotypes of the parents and offspring? What genotypes would you expect for any future offspring this couple might have?

12. A woman is married for a second time. Her first husband was blood type A and her child from that marriage was blood type O. Her new husband is blood type B, her child from this second marriage is blood type AB. What is the woman's genotype and blood type?

## Sex-Linked Problems

1. Distinguish between sex chromosomes and autosomes.
2. Discuss the pattern of inheritance of sex-linked characteristics and explain why recessive sex-linked characteristics are expressed more often in males than in females.
3. List several sex-linked traits.

4. What is the method of sex determination in Drosophila and humans.
5. A young couple has come to you for genetic counseling. The wife has a brother with muscular dystrophy (DMS) and they are concerned about having a child with DMS. What is the probability that their child will have DMS? (DMS [Duchennes muscular dystrophy is a sex-linked gene.)
6. Marvin is red-green colorblind and his wife is a carrier for green-blue colorblindness. What can you predict about their children?
7. A particular sex-linked recessive disease of humans is usually fatal. Suppose that, by chance, a boy with the disease lives past puberty and fathers a child by a woman who is heterozygous for the lethal trait. If they have a daughter, what is the probability that she will have the disease?
8. The rare trait called ocular albinism (which is almost complete absence of eye pigment) is inherited as a sex-linked recessive. A man with ocular albinism marries a woman who neither has this condition nor is a carrier. What possible offspring can this couple produce?
9. Red-green color blindness is caused by a sex-linked recessive gene. If a color-blind woman marries a man who has normal vision, what will be the phenotypes of their children?
10. A man and his wife are both normal but a daughter has fragile X syndrome. (Fragile X syndrome is a sex-linked recessive trait that occurs because the X chromosome has several repeats at a certain location on the chromosome preventing the chromosome from coiling up during prophase of mitosis and meiosis. This abnormal chromosome is easily seen in the microscope. It causes several distinguishing features: ears that stick straight out from the head, reduced intelligence (IQ = 35 to 65%), unpredictable violence and aggression, etc.) The man sues his wife for divorce on the grounds of infidelity. Can genetics provide evidence supporting his case? Explain.

## MORE SEX LINKAGE

1. For Drosophila, determine the probable genotypic and phenotypic ratios expected from a cross between a heterozygous female and red-eyed male, a heterozygous female and a white-eyed male, and red-eyed male Drosophila and a white-eyed female.
2. A man with hemophilia (a recessive sex-linked condition, symbolized by the letter "h") has a normal daughter. She marries a man who is normal. What is the probability that one of their daughters will be a hemophiliac? What is the probability that a son will be a hemophiliac?A woman whose father was a hemophiliac, but who is not herself a hemophiliac marries a man who is normal.
    a) What is the chance of hemophilia in her sons?
    b) In her daughters?
3. A woman and a man, both with normal blood clotting, have a normal son, a hemophiliac son, and two normal daughters. What is the probable genotype of each family member?
4. Suppose that gene "b" is sex-linked, recessive, and lethal. A man marries a woman who is heterozygous for this gene. If this couple had many normal children what would be the predicted sex ratio (males/females) of their children?
5. Colorblindness is a sex-linked recessive condition. A color blind man marries a woman with normal vision whose father was color blind. What is the probability that one of their daughters is color blind? What is the probability that one of their sons is color blind?

6. A color blind man mates with a normal-visioned woman and produces a color blind son and a normal visioned daughter. What are the genotypes for each of these four individuals?
7. Two normal visioned parents produce a color-blind son. What are the genotypes of the parents? What are the chances of their next child being a colorblind daughter?
8. In people, migraine, (a type of severe headache), is due to a dominant gene M. A normal visioned woman who never had a migraine takes her daughter to the doctor. The doctor discovers that the girl is colorblind and has migraine. What does he know about the father?
9. In people, brown eyes, B, are dominant to blue, b. (note: things are actually more complex, but just pretend that this how it works). A normal-visioned, brown-eyed woman, whose father was color-blind and blue-eyed, marries a normal-visioned, blue-eyed man. What sorts of children can they have in regard to these traits?
10. It has been concluded that in goats beardedness is a sex-linked recessive characteristic. Likewise in goats short ears and long ears depend on a single pair of alleles, neither being dominant, the heterozygous condition leads to intermediate-eared.
    a) What is the genotype of a bearded long-eared male?
    b) What are the possible genotypes of a non-bearded short-eared female?
    c) A non-bearded long-eared male is mated with a non-bearded short-eared female. What are the genotypic and phenotypic ratios of the offspring?
    d) If the offspring in part C are mated what are the genotypic and phenotypic ratios of their offspring?
11. In cats, yellow is due to the gene "L", while black is due to its recessive allele "B". The heterozygous condition BL results in tortoise shell pattern. The alleles are sex-linked. What kinds of offspring would be expected from the mating of a black female and a yellow male? Give the phenotype and genotype ratios.
12. In cats, yellow( W) and black( B) are co-dominant, sex-linked traits. The co-appearance of alleles “B” and “W” produces a tortoise-shell pattern (patches of yellow and black.), What kinds of kittens would be produced by
    a) a black male and a yellow female?
    b) A black male and a tortoise-shell female?
13. In humans, Duchenne’s muscular dystrophy is a condition in which the muscles waste away ending with death in the very early teenage years. It is caused by a sex-linked recessive gene. The condition is found in boys, not girls. Why is it not expected in girls?
14. A family has 2 boys and 2 girls. One of the boys dies of Duchenne’s muscular dystrophy, the other kids grow up and marry. What are the chances of their children showing the trait?
15. In a certain plant, tall, T, is dominant to short, t. Red flowers, R, are dominant to white flowers, r. A gardener crosses a TtRr plant with a ttrr plant. Seeds from this cross produce 52 tall, red plants and 48 short, white plants. Explain these results.
16. Alleles A, B, and C are known to be linked. A crosses over with B ten percent of the time. A crosses over with C twenty percent of the time. Genes B and C cross over ten percent of the time. What is the sequence of the genes on the chromosome?

## Linkage and Recombination Problems

1. Construct a linkage map.

| Genes | Recombination frequency in (%) |
|---|---|
| s to t | 2% |
| t to u | 3% |
| s to u | 1% |

2. Construct a linkage map.

| Genes | Recombination frequency (%) |
|---|---|
| u to s | 11 |
| s to t | 4 |
| u to t | 7 |

3. From the following linkage data, construct a linkage map of genes a, b, c and d.

| Genes | Map units (centimorgans) |
|---|---|
| d and c | 10 cM |
| c and a | 13 cM |
| a and d | 3 cM |
| b and c | 18 cM |
| b and d | 8 cM |

4. In Drosophila, the black body allele (b), is recessive to the wild type gray allele (b+). The curved wing allele (cu) is recessive to the wild type straight wing allele (cu+). The loci for these two traits are linked. A gray bodied, straight winged fly, homozygous for each trait, was mated with a black bodied, curved wing fly. An F1 female was then mated in a testcross with a male having a black body and curved wings.
   a. Identify the phenotypes expected among the testcross progeny if there is no crossing over.
   b. Identify the phenotypes expected among the testcross progeny if there is some crossing over between these two loci.
   c. Would you expect the phenotypes listed in (b) to occur in equal frequencies? Explain why or why not.

5. The allele for black body color in fruit flies is recessive to the allele for wild type normal color, and the allele for vestigial wings is recessive to the allele for normal wing form. A female fly heterozygous for both traits was crossed with a black bodied male with vestigial wings. The progeny phenotypes are their frequencies were normal color, normal wings: 252; black color, normal wings: 52; normal color, vestigial wings: 48; and black color, vestigial wings: 248.
   A. Do the results of this testcross support the hypothesis that the genes for these two traits are linked? Explain.
   B. If the loci are linked, what is the percent of recombination?

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