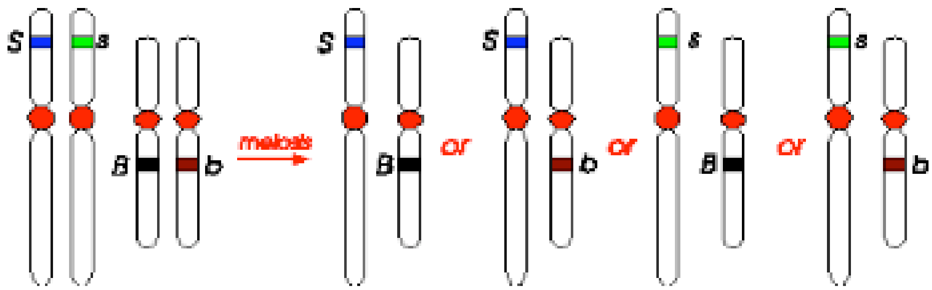
# Genetics Practice Problems II

**Dihybrid crosses:**

**Remember to consider the chromosomes and how they are sorted into the gametes in meiosis when doing dihybrid crosses! It's easy to get lost in the symbols and create Punnet squares that are biologically impossible.**




**Steps for solving dihybrid cross problems using Punnet squares:**

Step 1: Figure out the genotypes of the parents.
Step 2: Figure out what kinds of gametes the parents can produce.
Step 3: Set up a Punnett Square for your cross. Remember that what you put at the head of each column and row represents what can go in the gametes, so you have to account for both chromosomes in each row or column.
Step 4: Fill in the offspring inside the table.
Step 5: Figure out the genotypic ratio for your predicted offspring.
Step 6: Figure out the phenotypic ratio for your predicted offspring.
Step 7: Answer the question you've been asked.

**Steps for solving dihybrid cross problems using probability (easier once you get the math):**

Step 1: Figure out the genotypes of the parents.
Step 2: Treat each trait separately as a monohybrid cross problem.
Step 3: Determine the decimal percentage of each phenotype for trait A, and for trait B. (For example, 75% BB or Bb and 25% bb translates to 0.75 BB or Bb and 0.25 bb)
Step 4: Multiply the decimal percentage for the desired phenotypes to get the probability of inheriting both phenotypes. (example: If the odds of inheriting the dominant trait A is 0.75 and the odds of inheriting the dominant trait B is 0.75, then the odds of inheriting both traits is 0.75 x 0.75 = .56, or 56% which can also be expressed as 9/16)

1. In summer squash, white fruit color (W) is dominant over yellow fruit color (w) and disk-shaped fruit (D) is dominant over sphere-shaped fruit (d).
   a. If a squash plant true-breeding for white, disk-shaped fruit is crossed with a plant true-breeding for yellow, sphere-shaped fruit, what will the phenotypic ratios be for their offspring (the F1 generation)?

   The pure-breeding plant with white, disk-shaped fruit has the genotype WWDD. The only combination of these traits that it can put in its gametes would be WD. The plant with yellow, spherical fruit has the genotype of wwdd. It can only put wd in its gametes. Therefore all offspring of this cross will have the genotype WwDd for these traits, and will all have white, disk-shaped fruits.

   b. if two individuals from the F1 generation are crossed, what will the phenotypic ratios of the next generation (the F2 generation) be?

   This will result in the classic 9:3:3:1 ratios of 9/16 white disk, 3/16 white spherical, 3/16 yellow disk, and 1/16 yellow spherical. To set up the Punnet square, both sets of parents will have the following possible combinations of alleles in their gametes: WD, Wd, wD, wd

2. In Guinea pigs the allele for short hair (**S**) is dominant over the allele for long hair (**s**). *(Note that although short hair is "little hair" the allele symbol is "big S" because it's dominant.)* The allele for black hair (**B**) is dominant over the allele for brown hair (**b**). (Note: please don't try this at home. The chance of death for Guinea pig sows *and* their pups during pregnancy and birth is between 20 and 25%, and too many unwanted Guinea pigs are euthanized in animal shelters already.)

   a. Suppose two Guinea pigs, both heterozygous for both traits, are mated. What are the odds of any one of their pups being Both parents will have the genotype SsBb for these traits.
   Possible gametes: SB, Sb, sB, sb

   short-haired and black? 0.56, or 9/16

   short-haired and brown? 0.19, or 3/16

   long-haired and black? 0.19, or 3/16

   long haired and brown? 0.06, or 1/16

   b. Suppose that a Guinea pig boar that is heterozygous for both traits is mated with a sow that is heterozygous for fur (Ss), but whose fur is brown (bb). What are the odds of any one of their pups being:
   Boar's genotype: SsBb, possible gametes: SB, Sb, sB, sb
   Sow's genotype: Ssbb, possible gametes: Sb, sb

   short-haired and black? 0.375, or 6/16

   short-haired and brown? 0.375, or 6/16

   long-haired and black? 0.125, or 2/16

   long haired and brown? 0.125, or 2/16

**Incomplete dominance and co-dominance**

Some pairs of alleles aren't fully dominant or recessive. In these special cases, the heterozygotes seem to have both inherited traits or a blend of both traits. This is because both alleles are expressed equally. "Incomplete dominance" is where the traits appear to blend. An example is the Four-o'clock flower, where white-flowered plants crossed with red-flowered plants can produce pink-flowered plants. An example of co-dominance is the color "roan" in horses and other animals, where a red-coated horse crossed with a white-coated horse can produce a foal with a roan coat (both white and red hairs). The underlying genetics in both cases are the same. Instead of **A** or **a** to express dominant or recessive alleles, we usually use two small letters. For example, the allele for red flowers in Four-o'clocks is often expressed as **r**, and the allele for white flowers is **w**.

1. A purebreeding red-flowered Four-o'clock (rr) is crossed with a purebreeding white-flowered Four-o'clock (ww). What colors will be seen in the resulting offspring? What will their genotypes be?

   All offspring will be pink, and all will be rw.

2. If two offspring from the above cross are crossed with each other, what colors will be seen in the resulting offspring? What will be the genotypes of the resulting offspring?

   rw x rw: 25% red (rr), 50% pink (rw), 25% white (ww)

3. A black cat breeds with a tan cat and their kittens are all black-and-tan tabby (striped or mottled) cats. Set up a Punnet square that shows how this could happen. Is this incomplete dominance or co-dominance?

Your Punnet square should show one black cat as bb, one tan cat as tt, and all their kittens as bt. This is an example of co-dominance.

4. If two black-and-tan tabby cats, with genotypes that are like the kittens in problem 3, are bred, what are the odds of any one of their kittens being tabby? All black? All tan?

Both parents would be bt. In a cross between bt x bt, the kittens would be: 25% black (bb), 50% tabby (bt), and 25% tan (tt)

**X-linked traits**

An X-linked trait is one that is controlled by a gene on the X chromosome. Because men inherit only one X chromosome while women inherit two, the patterns of X-linked inheritance are a little different than the patterns for normal monohybrid crosses. To track the inheritance of X-linked traits, it is important to use symbols for the X and Y chromosomes themselves, and attach the symbol for the gene in question to the X.

1. Color blindness is also a recessive X-linked gene. Let's denote the normal and mutant alleles as Xb+ and Xb respectively. A woman with genotype Xb+/Xb marries a man of genotype Xb/Y.

   a. What are the odds that any one of their sons will be color blind?
   50% chance that any one of their *sons* will be color blind.

   b. What are the odds that any one of their daughters will be color blind?
   None of their daughters will be color blind.

   c. What are the odds that any one of their will be carriers for the Xb allele?
   50% chance that any one of their daughters will be carriers.

2. Duchene Muscular Dystrophy (DMD) is a severe form of muscular dystrophy that is caused by a recessive allele on the X chromosome. Children who inherit this disorder usually die in childhood. Suppose that a woman and a man who do not have DMD have a son who is diagnosed with DMD.

   a. From which parent did the boy inherit the DMD allele?
   From his mother (he could not have gotten the X chromosome from his father).

   b. What are the odds that any of their next sons will have DMD?
   50% chance that any one of their *sons* will have DMD.

   c. What are the odds that any one of their daughters be a carrier for DMD?
   50% chance that any one of their daughters will be carriers.

   d. Why is it virtually impossible for a girl to be born with DMD?
   Because she would have to have a father with DMD, but children born with DMD do not live long enough to reproduce.

3. In fruit flies, sex linkage works very much like it does in humans. Normal flies have red eyes. A recessive gene that causes white eyes is found on the X chromosome. (The gene codes for an enzyme that is one of a series of enzymes that makes red pigment. If the enzyme is defective, the pigment can't be made.) If a white-eyed male is mated to a female that is red-eyed but a carrier for the white-eye gene, what proportion of their offspring would be:

   a. red-eyed males
   25%

   b. red-eyed females
   25%

   c. white-eyed males
   25%

   d. white-eyed females
   25%

**Multiple alleles**

Some genes have more than two alleles. One example of this is human ABO blood type. The gene for a protein on the surface of the red blood cell comes in three alleles: the A allele, which makes A protein, the B allele, which makes B protein, and the O allele, which makes neither protein. O is considered recessive to the other two. A and B are co-dominant. Thus someone whose genotype is AB will have AB blood; OO will produce type O blood; AA or AO will produce type A blood, and BB or BO will produce type B blood.

1. A man with AB blood marries a woman with type O blood. What are the possible phenotypes and genotypes of their children?

| | | |
|---|---|---|
| A cross between AB and OO produces | Genotypes | Phenotypes: |
| | AO | type A |
| | BO | type B |

2. A man with type B blood marries a woman with type A blood. Their first child has type O blood. The man says this is impossible and accuses his wife if infidelity.

   a. Is it possible for these two people to produce a type O child?
      Yes. They could both be carriers of the O allele.

   b. What are the genotypes of both parents?
      Mother: AO        Father: BO

   c. Draw a Punnet square to show the possible blood types of their children.
      This cross should result in possible genotypes AB, AO, BO, and OO

3. A woman names her former boyfriend in a paternity suit. Her child is blood type A. The woman has blood type AB. The accused man has blood type B.

   a. Is it possible for this man to be the child's father? Draw a Punnet square to defend your answer.

      It is possible, if the man's genotype is BO. This could result in a child with genotype AO.

   b. Does this evidence provide positive proof in this case?
      No. It shows it is possible for this man to be the father of the child, but does not prove that he is. The child could have been fathered by a man with type A (AA or AO) or type O blood as well, or by some other man with type B blood.

   c. Suppose the woman had blood type O. Is it possible for the man to be the father of the child? Why or why not?
      He could not be the father in this case. The child had to get the A allele from somewhere, and if the mother could not donate it, then it had to come from the father.

4. In a similar paternity case, the woman has type A blood, the man has type B blood, and the child has type AB.

   a. Is it possible for this man to be the child's father? Draw a Punnet square to defend your answer.
      Yes. The child could have gotten the A allele from the woman and the B allele from the man.

   b. Does this evidence provide positive proof in this case?
      No. Another man with type AB blood, or a man with type B blood, could be the father.