

Punnett Square  
Practice Problems

Name Key Hour \_\_\_\_\_

Gamete Formation

1. Kelp, a large, multicellular type of algae, has air bladders in the blades to help them float near the surface of the ocean where they can get more sunlight. Assume that having many air bladders is a dominant trait. What gametes would be produced by a heterozygous individual?

Key M_ = many air bladders mm = less air bladders	Genotype Mm	Gametes (M) or (m) 50% each
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What gametes would be produced by a homozygous dominant individual?

Genotype MM	Gametes (M) 100%
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2. In humans, sickle cell anemia is a disease caused by a mutation of a single locus gene that codes for an important blood protein. The allele for the normal protein is dominant to that for the one causing sickle cell anemia. What gametes would be produced by an individual who suffers from sickle cell anemia?

Key S_ = normal ss = sickle cell	Genotype ss	Gametes (s) 100%
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What gametes would be produced by individuals resulting from a homozygous dominant x homozygous recessive cross? SS x ss

Cross (S) (s) (s) Ss	Resulting genotype Ss	Gametes (S) or (s) 50% of each
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3. In areas of the very deep and damp southeastern United States lives what is, essentially, a giant flying cockroach known as a Palmetto bug. Assume that long antennae are dominant to short antennae and that normal wings are dominant to bent ones. What gametes will be produced by an individual that is homozygous dominant for antennae and heterozygous for wings?

Key L_ = long antennae ll = short antennae N_ = normal wings nn = bent wings	Genotype LLNn	Gametes (LN) or (Ln) 50% of each
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What gametes will be produced by an individual that is heterozygous for antennae and homozygous recessive for wings?

Genotype $Ll\ nn$	Gametes $(Ln)$ or $(ln)$ 50% of each
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4. In horses, the color black is due to a dominant allele and chestnut color is due to the recessive allele. The trotting gait is due to a dominant allele and the pacing gait to the recessive. What will be the gametes produced by a homozygous black pacer?

Key $B\_ = \text{Black}$ $bb = \text{chestnut}$ $T\_ = \text{trotting}$ $tt = \text{pacing}$	Genotype $BBtt$	Gametes $(Bt)$ 100%
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Suppose we cross the black pacer above with a homozygous chestnut trotter. What will be the gametes produced by the offspring?

Parental Genotypes $BBtt \times bbTT$	Parental Gametes $(Bt) \times (bT)$	Cross $(Bt)$ $(bT) \ BbTt$
Resulting genotype of offspring $BbTt$	Gametes produced by the offspring $(BT)$ $(Bt)$ $(bT)$ $(bt)$ 25% chance of each	

5. Suppose you are designing a new Jurassic Park and you would like to have the crowd drawing presence of Velociraptor without the danger of having your crowds eaten. You have managed to come up with two varieties, very aggressive, which is apparently a dominant trait in Velociraptors, and non-aggressive. They also come in two colors, red, which is dominant, and green. Now you have a green female that is homozygous dominant for aggression and a non-aggressive male that is homozygous dominant for color. What gametes will be produced by the male and female?

Key $A\_ = \text{Aggressive}$ $aa = \text{not aggressive}$ $R\_ = \text{red}$ $rr = \text{green}$	Parental Genotypes ♀ $rrAA$ ♂ $RRaa$	Parental Gametes $(rA)$ $(Ra)$
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What gametes will be produced by the offspring of these two Velociraptors (providing of course that the female doesn't dismember the male before mating)?

<p>Cross</p> <p><math>(rA)</math></p> <p><math>(Ra)</math> <math>RrAa</math></p>	<p>Resulting genotype of the offspring</p> <p><math>RrAa</math></p>	<p>Gametes produced by the offspring</p> <p><math>(RA)</math> <math>(Ra)</math> <math>(rA)</math> <math>(ra)</math></p> <p>25% chance of each</p>
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### Monohybrid Crosses

1. In rabbits the allele for black coat color is dominant over the allele for brown coat color. What would the genotypic ratio and phenotypic ratio be for a cross between an animal homozygous for black coat color and one homozygous for brown coat color?

<p>Key</p> <p><math>B_ = black</math></p> <p><math>bb = brown</math></p>	<p>Parental genotypes</p> <p><math>BB \times bb</math></p>	<p>Parental gametes</p> <p><math>(B) \times (b)</math></p>
<p>Cross</p> <p><math>(B)</math></p> <p><math>(b)</math> <math>Bb</math></p>	<p>Genotypic description and Ratio</p> <p>100% <math>Bb</math> (heterozygous)</p>	<p>Phenotypic description and Ratio</p> <p>100% Black</p>

2. White hair in sheep is caused by the dominant gene while black hair is recessive. A heterozygous white male and a black female are parents of a black lamb. What is the probability that their next lamb will be white? What are the genotypic and phenotypic ratios?

<p>Key</p> <p><math>W_ = White</math></p> <p><math>ww = black</math></p>	<p>Parental genotypes</p> <p><math>\sigma = Ww</math></p> <p><math>\text{♀} = ww</math></p>	<p>Parental gametes</p> <p><math>(W)</math> or <math>(w)</math></p> <p><math>(w)</math></p>
<p>Cross</p> <p><math>(W)</math> <math>(w)</math></p> <p><math>(w)</math> <math>Ww</math> <math>ww</math></p>	<p>Probability next lamb is white</p> <p>50% chance next lamb is white</p>	<p>Genotypic description and Ratio</p> <p><math>Ww : ww</math></p> <p>1 : 1</p>
<p>Phenotypic description and Ratio</p> <p>white : Black</p> <p>1 : 1</p>		

3. Albinism is recessive in humans. An albino man marries a woman who is not albino, but had an albino father. What is the probability of this couple having a child that is not an albino? What are the genotypic and phenotypic ratios?

Key A <sub>-</sub> = Not albino aa = albino	Parental genotypes ♂ = aa ♀ = Aa	Parental gametes a A or a
Cross A a a Aa aa	Probability child is not albino 50% chance child is not albino	Genotypic description and Ratio Aa : aa 1 : 1
Phenotypic description and Ratio Not albino : albino 1 : 1		

4. Todd and Melissa are college students who are planning to get married. They are currently taking a genetics course and decided to determine the eye color of any possible children they might have. Blue eyes are recessive to brown eyes. Todd has brown eyes, like his three brothers. His mother and grandmother have blue eyes, but his father and all other grandparents have brown eyes. Brown eyed Melissa has one blue eyed sister and one brown eyed sister and a mother with blue eyes. Her father and all of her grandparents have brown eyes. Construct an accurate Punnett square to determine the possible eye colors of their yet to be born children. What are the genotypic and phenotypic ratios?

Key B <sub>-</sub> = Brown eyes bb = Blue eyes	Parental genotypes Todd Bb Melissa Bb	Parental gametes B b B b
Cross B B Bb b Bb bb	Genotypic description and Ratio BB : Bb : bb 1 : 2 : 1	Phenotypic description and Ratio Brown eyes : Blue eyes 3 : 1

5. In Teenage Mutant Ninja Turtles, green shells are dominant over brown shells. Leonardo, who is heterozygous for a green shell, marries the lovely Mona Lisa, who has a brown shell. What are the genotypic and phenotypic ratios of their possible offspring?

Key G <sub>-</sub> = green shells gg = brown shells	Parental genotypes Leonardo Gg Mona Lisa gg	Parental gametes G g g
Cross G g g Gg gg	Genotypic description and Ratio Gg : gg 1 : 1	Phenotypic description and Ratio Green shell : brown shell 1 : 1

6. In humans, polydactyly (an extra finger on each hand or toe on each foot) is due to a dominant gene. When one parent is polydactylous, but heterozygous, and the other parent is normal, what are the genotypic and phenotypic ratios of their possible offspring?

Key F <sub>-</sub> = polydactyl ff = normal	Parental genotypes Ff × ff	Parental gametes F or f × f
Cross Ff × ff	Genotypic description and Ratio Ff : ff 1 : 1	Phenotypic description and Ratio Polydactyl : normal 1 : 1

### Dihybrid Crosses

1. In human, aniridia, (a type of blindness resulting from absence of an iris) is due to a dominant gene. Migraine (a sickening headache) is due to a different dominant gene. A man with aniridia, whose mother was not blind, marries a woman who suffers from migraine. The woman's father did not suffer from migraine. In what proportion of their children would both aniridia and migraine be expected to occur?

Key A <sub>-</sub> = aniridia aa = normal M <sub>-</sub> = migraine mm = normal	Parental genotypes ♂ Aamm ♀ aaMm	Parental gametes Am am aM am
Cross Am am aM aM am am AaMm aaMm Aamm aamm	Proportion of Children with both aniridia and migraine 25% <del>chance</del> chance of having child w/ both Aniridia and Migraines	

2. In watermelons, solid green color is dominant over striped pattern, and short shape is dominant over long shape. What is the probability of each phenotype of possible offspring if a heterozygous solid, long watermelon cross pollinates with a heterozygous solid, heterozygous short watermelon?

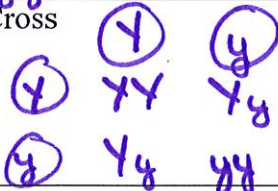
<p>Key  <math>G_{-}</math> = solid green  <math>gg</math> = striped  <math>S_{-}</math> = short  <math>ss</math> = long</p>	<p>Parental genotypes  <math>Ggss \times GgSs</math></p>	<p>Parental gametes  <math>(Gs)</math> or <math>(gs)</math>  <math>\times</math>  <math>(GS)</math> <math>(Gs)</math> <math>(gS)</math> <math>(gs)</math></p>
<p>Cross</p> <p><math>(GS)</math> <math>(Gs)</math> <math>(gS)</math> <math>(gs)</math></p> <p><math>(Gs)</math> <math>GGsS</math> <math>Ggss</math> <math>GgSs</math> <math>Gyss</math></p> <p><math>(gs)</math> <math>GgSs</math> <math>Ggss</math> <math>ggSs</math> <math>ggss</math></p>	<p>Description and probability of each possible phenotype</p> <p>Solid Green + short = <math>\frac{3}{8}</math> (37.5%)</p> <p>Striped + short = <math>\frac{3}{8}</math> (37.5%)</p> <p>Solid Green + long = <math>\frac{1}{8}</math> (12.5%)</p> <p>Striped + long = <math>\frac{1}{8}</math> (12.5%)</p>	

3. Having two eyebrows is dominant over having one large eyebrow (uni-brow). Also having six fingers is dominant over having five fingers. What is the probability of each possible phenotype of their offspring if a man that has one eyebrow and is heterozygous for having six fingers reproduces with a woman that is heterozygous for both traits?

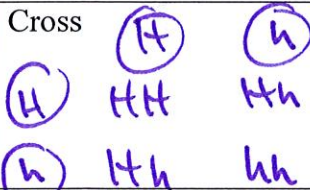
<p>Key  <math>E_{-}</math> = two eyebrows  <math>ee</math> = unibrow  <math>F_{-}</math> = six fingers  <math>ff</math> = five fingers</p>	<p>Parental genotypes  <math>\text{♂ } eeFf</math>  <math>\text{♀ } EeFf</math></p>	<p>Parental gametes  <math>(eF)</math> <math>(ef)</math>  <math>(EF)</math> <math>(Ef)</math> <math>(eF)</math> <math>(ef)</math></p>
<p>Cross</p> <p><math>(EF)</math> <math>(Ef)</math> <math>(eF)</math> <math>(ef)</math></p> <p><math>(eF)</math> <math>EeFF</math> <math>EeFf</math> <math>eeFF</math> <math>eeFf</math></p> <p><math>(ef)</math> <math>EeFf</math> <math>Eeff</math> <math>eeFf</math> <math>eeff</math></p>	<p>Description and probability of each possible phenotype</p> <p>Two brows + six fingers = <math>\frac{3}{8}</math> (37.5%)</p> <p>Two brows + five fingers = <math>\frac{1}{8}</math> (12.5%)</p> <p>Uni-brow + six fingers = <math>\frac{3}{8}</math> (37.5%)</p> <p>Uni-brow + five fingers = <math>\frac{1}{8}</math> (12.5%)</p>	

## Incomplete Dominance

1. Yellow coat color in guinea pigs is produced by the homozygous genotype, and cream color by the heterozygous genotype. White is produced by the homozygous genotype. What genotypic ratios are expected by crosses between cream colored guinea pigs? Describe the phenotypic ratio.


Key YY = Yellow Yy = Cream yy = white	Parental genotypes Yy x Yy	Parental gametes Y or y x Y or y
Cross 	Genotypic description and Ratio YY : Yy : yy 1 : 2 : 1	Phenotypic description and Ratio Yellow : Cream : White 1 : 2 : 1

2. In humans hair texture is controlled by incomplete dominance. A curly haired individual and a straight haired individual have all wavy haired children. If two wavy haired people have children, what will the phenotypic ratio be?

Key HH = Curly Hh = Wavy hh = straight	Parental genotypes Hh x Hh	Parental gametes H or h x H or h
Cross 	Phenotypic description and Ratio Curly : Wavy : straight 1 : 2 : 1	

3. In Japanese four o'clock flowers, color is inherited by genes that show incomplete dominance. In such flowers, a cross between a homozygous red flower and a homozygous white flower will always result in pink flowers.

- a. What is the genotypic and phenotypic ratio for a cross between a plant with red flower and a plant with pink flowers?

Key RR = red Rr = pink rr = white	Parental genotypes RR x Rr	Parental gametes R x R or r
Cross 	Genotypic description and Ratio RR : Rr 1 : 1	Phenotypic description and Ratio Red : Pink 1 : 1

- b. A plant breeder wants to produce only pink Japanese four o'clock flowers. Can he do so by crossing pink Japanese four o'clock flowers with white Japanese four o'clock plants? Use a Punnett square to support your answer.

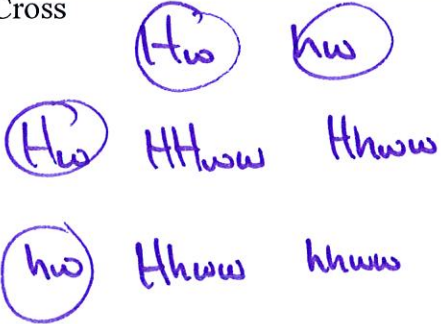
<p>Cross</p> $Rr \times rr$ $\begin{array}{cc} R & r \\ r & Rr & rr \end{array}$	<p>Resulting phenotypes</p> <p>50% Pink 50% White</p>	<p>Possible?</p> <p>No</p>
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4. Hair texture in humans is incompletely dominant. Curly hair plus straight hair gives you wavy hair. Also, having 2 eyebrows is dominant over one eyebrow. If two individuals are heterozygous for both traits, what is the probability of each phenotype in their future offspring?

<p>Key</p> <p>HH = Curly Hh = Wavy hh = Straight E_ = two brows ee = uni-brow</p>	<p>Parental genotypes</p> <p>HhEe <math>\times</math> HhEe</p>	<p>Parental gametes</p> <p>both can make</p> <p><math>\begin{array}{cccc} HE &amp; He &amp; hE &amp; he \end{array}</math></p>
<p>Cross</p> $\begin{array}{cccc} HE & He & hE & he \\ HE & HHEE & HHEe & HhEE & HhEe \\ He & HHEe & HhEe & HhEe & hhee \\ hE & HhEE & HhEe & hhEE & hhEe \\ he & HhEe & HhEe & hhEe & hhee \end{array}$	<p>Description and probability of each possible phenotype</p> <p>Curly, 2 brows = <math>\frac{3}{16}</math> (18.75%)  Wavy, 2 brows = <math>\frac{6}{16}</math> (37.5%)  Straight, 2 brows = <math>\frac{3}{16}</math> (18.75%)  Curly, uni-brow = <math>\frac{1}{16}</math> (6.25%)  Wavy, uni-brow = <math>\frac{2}{16}</math> (12.5%)  Straight, uni-brow = <math>\frac{1}{16}</math> (6.25%)</p>	




5. Remember that hair texture is incompletely dominant. (With a curly hair person that mates with a straight hair person resulting in wavy hair children). Widow's peak is dominant to not having a widow's peak. If a couple has wavy hair and both do not have a widow's peak, what is the phenotypic ratios of the children?

<p>Key  <math>HH</math> = Curly  <math>Hh</math> = Wavy  <math>hh</math> = straight  <math>W_</math> = Widow's Peak  <math>ww</math> = no widow's peak</p>	<p>Parental genotypes  <math>Hhww \times Hhww</math></p>	<p>Parental gametes  <math>(Hw)</math> or <math>(hw)</math>  <math>\times</math>  <math>(Hw)</math> or <math>(hw)</math></p>									
<p>Cross</p> 	<p>Description and probability of each possible phenotype</p> <table border="0"> <tr> <td>Curly &amp; no peak</td> <td><math>\frac{1}{4}</math></td> <td>(25%)</td> </tr> <tr> <td>Wavy &amp; no peak</td> <td><math>\frac{1}{2}</math></td> <td>(50%)</td> </tr> <tr> <td>Straight &amp; no peak</td> <td><math>\frac{1}{4}</math></td> <td>(25%)</td> </tr> </table>		Curly & no peak	$\frac{1}{4}$	(25%)	Wavy & no peak	$\frac{1}{2}$	(50%)	Straight & no peak	$\frac{1}{4}$	(25%)
Curly & no peak	$\frac{1}{4}$	(25%)									
Wavy & no peak	$\frac{1}{2}$	(50%)									
Straight & no peak	$\frac{1}{4}$	(25%)									

### Codominance

1. In shorthorn cattle, the hybrid between red and white is roan, having red and white hairs intermingled. If a roan is bred with a white, what will the phenotypic ratio be?

<p>Key  <math>C^R C^R</math> = red coat  <math>C^R C^W</math> = roan coat  <math>C^W C^W</math> = white coat</p>	<p>Parental genotypes  <math>C^R C^W \times C^W C^W</math></p>	<p>Parental gametes  <math>(C^R)</math> or <math>(C^W)</math>  <math>\times</math>  <math>(C^W)</math></p>
<p>Cross</p> 	<p>Phenotypic description and Ratio</p> <p>Roan: White coat          (: 1)</p>	

## Multiple Alleles / Codominance

1. Suppose a man who is homozygous for type A blood marries a woman with type AB blood. What blood types would you expect to find among their children?

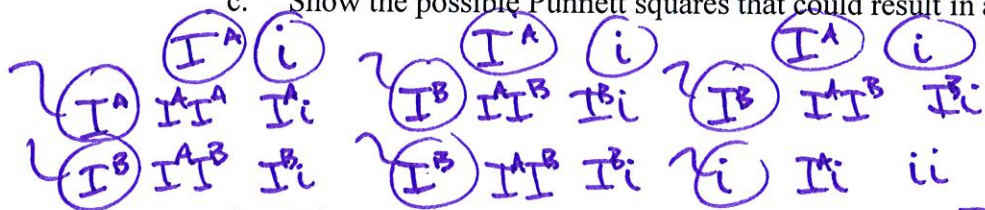
Key $I^A I^A$ or $I^A i$ = Type A $I^A I^B$ = Type B	Parental genotypes ♂ $I^A I^A$ ♀ $I^A I^B$	Parental gametes $I^A$ $I^A$ or $I^B$
Cross $I^A$ $I^B$ $I^A I^A$ $I^A I^B$	Possible Blood types Type A or Type AB (50% chance of each)	

2. A man with type AB blood is married to a woman with type O and he questions the legitimacy of her child, who has type O blood. What should the legal judgment be?

Parental genotypes $I^A I^B$ = Type AB ♂ $ii$ = Type O ♀	Parental gametes $I^A$ $I^B$ $i$	Cross $I^A$ $I^B$ $i$ $I^A i$ $I^B i$
Possible Blood types of children Either Type A or Type B	Legal judgement The child is not his	

3. A child has blood type AB, and the mother has blood type A.

- a. What are the possible genotypes of the child's mother?  $I^A I^A$  or  $I^A i$   
 b. What is the genotype of the child?  $I^A I^B$   
 c. Show the possible Punnett squares that could result in a child with type AB blood



- d. What could be the possible genotypes of the father?  $I^A I^B$ ,  $I^B I^B$  or  $I^B i$   
 e. Could the father be type O? Explain. no b/c the child needs to get the  $I^B$  allele from somewhere

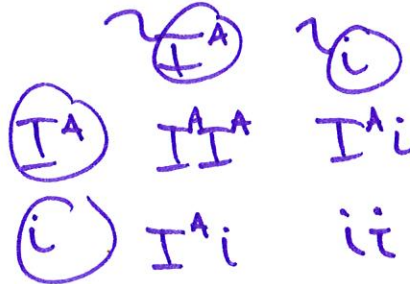
4. Mrs. Doe and Mrs. Jones had babies at the same hospital at the same time. Mrs. Doe took home a girl and named her Nancy. Mrs. Jones received a boy and named him Richard. However, Mrs. Jones was sure she had had a girl and brought a law suit against the hospital. Blood tests showed the Mr. Jones was type O. Mrs. Jones was type AB. Mr. and Mrs. Does were both type A. Nancy was type B and Richard was type O. Had an exchange occurred? Explain! (Use Punnett squares for evidence to support your claim)

Mr Jones =  $ii$   
Mrs Jones =  $I^A I^B$



Type A or Type B child possible

Mr Doe  $I^A I^A$  or  $I^A i$   
Mrs Doe  $I^A I^A$  or  $I^A i$



Type A or Type O child possible

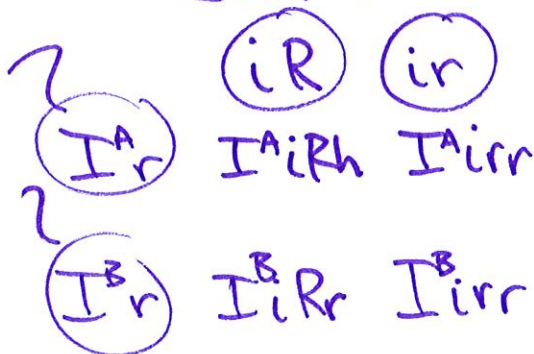
Since Nancy was type B and Richard was type O there must have been an accidental switch at the hospital.

5. Mike and Carol Brady are expecting their first child together. Mike, however, has noticed that Sam the Butcher has been hanging around the house at weird times and often when his lady friend Alice is not around. When baby Brady is born, Mike notices that its blood type is B+. Mike is concerned because he has AB- blood and Carol has O+. Sam the butcher has A+ blood. Is Mike just being silly and will they have this situation settled in 30 minutes, or will we get the "to be continued" message for paternity suits in upcoming episodes?

Baby Brady B+ ( $I^B i Rr$ )  
Mike Brady AB- ( $I^A I^B rr$ )  
Carol Brady O+ ( $ii Rr$ )  
Sam A+ ( $I^A i Rr$ )

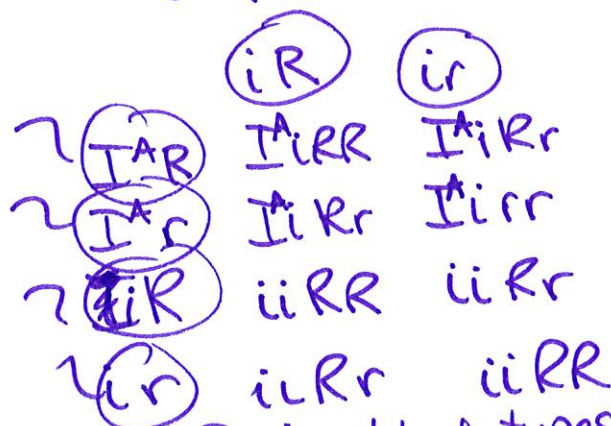
Mike is crazy, Carol + Sam could not have a B+ baby but he + Carol could.

Carol x Mike



Possible blood types:  
A+, A-, B+ or B-



Carol x Sam



Possible blood types:  
A+, A-, O+ or O-

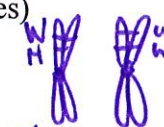

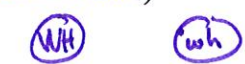

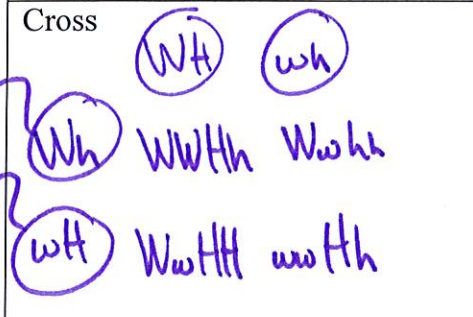
## Linked Gene Problems

1. 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. In addition, 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 and large eyes being the dominant alleles for each. Lastly, assume that these genes are linked closely on the same chromosome. 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. What are the possible genotypes of their offspring?

<p>Key</p> <p><math>L</math> = Lights  <math>ll</math> = no lights  <math>Ee</math> = Big eyes  <math>ee</math> = no eyes</p>	<p>Parental genotypes (show with chromosomes)</p> <p>♀ <math>LLEe</math> </p> <p>♂ <math>LLee</math> </p>	<p>Parental gametes (show with chromosomes)</p> <p><math>LE</math> <math>le</math></p> <p><math>Le</math></p>
<p>Cross</p> <p><math>LE</math> <math>le</math></p> <p><math>Le</math> <math>LLEe</math> <math>Llee</math></p>	<p>Possible genotypes of offspring</p> <p>50% <math>LLEe</math></p> <p>50% <math>LLee</math></p>	<p>50% Lights + eyes</p> <p>50% Lights no eyes</p>

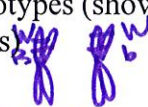

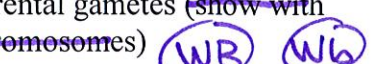

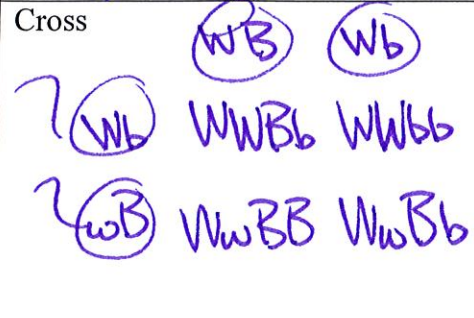
What are the possible phenotypes of the offspring of the cross above?

2. 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 and hair between the toes 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. What percentage of each genotype will be produced?

<p>Key  <math>W_</math> = wide paws  <math>w</math> = narrow paws  <math>H_</math> = hair b/w toes  <math>h</math> = no hair</p>	<p>Parental genotypes (show with chromosomes)</p> <p>♀ <math>WwHh</math></p>  <p>♂ <math>WwHh</math></p> 	<p>Parental gametes (show with chromosomes)</p>  
<p>Cross</p> 	<p>Description and probability of each possible phenotype</p> <p>Wide paws w/ hair <math>\frac{1}{2}</math> (50%)</p> <p>Wide paws no hair <math>\frac{1}{4}</math> (25%)</p> <p>Narrow paws w/ hair <math>\frac{1}{4}</math> (25%)</p>	

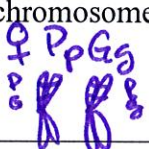

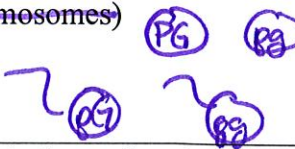
What percentage of the offspring will have narrow paws with hair between the toes? 25%

3. 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 is dominant to black spots and that black eyes are dominant to pink eyes. You decide to cross a female that is homozygous dominant for hair color (you just happen to know the genotype of each mouse since they've been in this lab breeding population for several generations) 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. What genotypic ratio do you expect in the offspring?

<p>Key  <math>W_</math> = plain white  <math>w</math> = black spots  <math>B_</math> = black eyes  <math>b</math> = pink eyes</p>	<p>Parental genotypes (show with chromosomes)</p> <p>♀ <math>WWBb</math></p>  <p>♂ <math>WwBb</math></p> 	<p>Parental gametes (show with chromosomes)</p>  
<p>Cross</p> 	<p>Genotypic description and ratio</p> <p><math>WWBb : WWbb : WwBB : WwBb</math>  <math>1 : 1 : 1 : 1</math></p>	

What percentage of the offspring will have black spots and pink eyes? 0%



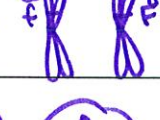






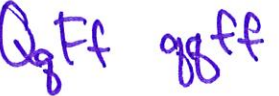




4. A group of spiders known as orb weavers often construct patterns with threads visible in the ultraviolet spectrum into the centers of their webs. These patterns mimic the centers of flowers and provide a lure for unwary flying insects that can see in the ultraviolet range. Suppose that in a particular 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 UV pattern that is a solid circle is dominant to the allele for a UV pattern that is a target pattern. The allele for green spots is dominant to the allele for 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. What percentage of each phenotype will be found in the offspring?

<p>Key  <math>P_{-}</math> = solid circle  <math>pp</math> = target  <math>G_{-}</math> = spots  <math>gg</math> = no spots</p>	<p>Parental genotypes (show with chromosomes)</p> <p>♀ <math>PpGg</math>  </p> <p>♂ <math>ppGg</math>  </p>	<p>Parental gametes (<del>show with chromosomes</del>)</p> <p><math>PG</math> <math>pg</math>  </p>
<p>Cross</p> <p><math>PG</math> <math>pg</math>  <math>pG</math> <math>PpGG</math> <math>ppGg</math>  <math>pg</math> <math>PpGg</math> <math>ppgg</math></p>		<p>Description and probability of each possible phenotype</p> <p>Solid circle + Spots = <math>\frac{1}{2}</math> (50%)          Target + Spots = <math>\frac{1}{4}</math> (25%)          Target + No spots = <math>\frac{1}{4}</math> (25%)</p>

What percentage (or fraction) will have the  $PpGg$  genotype? 25% ,  $\frac{1}{4}$

What percentage (or fraction) will have the  $ppgg$  genotype? 25% ,  $\frac{1}{4}$

5. A farmer who wants to get into the milk business has bought a small beginning herd of 12 cows all of which produce high quantities of milk (dominant over low quantities) and have high fertility (also dominant over low fertility). However, she knows that all of her cows are heterozygous for both these traits and that the genes are linked. In her cows, one homolog of the pair contains the dominant alleles for each trait and one contains the recessive allele of each of the traits. Two of the farmer's nearby neighbors own bulls that are also heterozygous for these traits. The first neighbor's bull has the same alleles linked as her cows but the second neighbor's bull has one dominant and one recessive allele from each trait on each homolog. Baring in mind that the farmer would like to obtain the maximum number of calves with high milk production and high fertility, which of the two available bulls should she choose to introduce her cows to?

<p>Key</p> <p>Q_ = high quantity          qq = low quantity          F_ = high fertility          ff = low fertility</p>	<p>Parental genotypes (show with chromosomes)</p> <p>♀ Qq Ff </p> <p>♂ 1 Qq Ff </p> <p>♂ 2 Qq Ff </p>	<p>Parental gametes (<del>show with chromosomes</del>)</p> <p></p> <p></p> <p></p>
<p>Cross 1</p> <p></p> <p></p> <p></p> <p></p>	<p>Cross 2</p> <p></p> <p></p> <p></p> <p></p>	<p>Which bull should be introduced?</p> <p>Cross 1</p>

What percentage of the offspring resulting from the best match above will have the most desirable **phenotype** of high milk production and high fertility? **Cross 1 75% high milk + high fert.**  
**Cross 2 only has 50% high milk + high fert.**

What percentage of the offspring resulting from the best match above will have the most desirable **genotype** of ~~MMFF?~~ **homozygous dominant for both traits?** **25% in cross 1**  
**0% in cross 2**

## Sex-Linked Genes

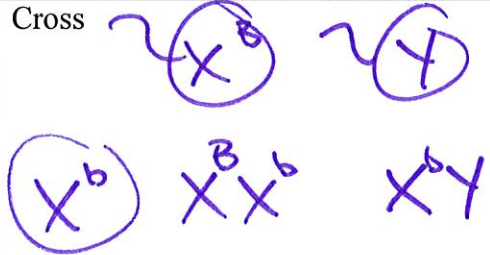
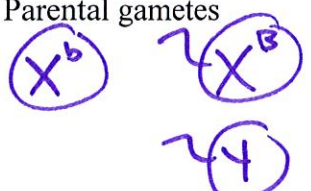
1. A boy, whose parents and grandparents had normal vision, is red-green color-blind. Red green color blindness is an x-linked recessive trait. What are the genotypes for his mother and his maternal grandparents?

<p>Key</p> <p><math>X^B X^B</math> - normal ♀</p> <p><math>X^b X^b</math> - colorblind ♀</p> <p><math>X^B Y</math> - normal ♂</p> <p><math>X^b Y</math> - colorblind ♂</p>	<p>Genotype of boy</p> <p><math>X^b Y</math></p>	<p>Genotype of mother</p> <p><math>X^B X^b</math></p>	<p>Genotype of maternal grandparents</p> <p><math>X^B X^b</math> grandma</p> <p><math>X^B Y</math> grandpa</p>
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2. A woman with red-green color-blindness has a mother with normal vision. Knowing that color-blindness is a sex-linked recessive gene, can you determine what her father's phenotype is? yes If so, what is it?

<p>Genotype of woman</p> <p><math>X^b X^b</math></p>	<p>Genotype of father</p> <p><math>X^b Y</math></p>	<p>For her to be colorblind she needed to get an X chromosome w/ the recessive allele from both her mom and her dad.</p>
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The woman marries a man with normal vision. What is the probability they will have sons who are red-green color-blind? What is the probability they will have daughters who are red-green color-blind?

<p>Parental genotypes</p> <p><math>X^b X^b \times X^B Y</math></p>	<p>Cross</p> 	<p>Probability of sons who are red-green colorblind</p> <p>100%</p>
<p>Parental gametes</p> 		<p>Probability of daughters who are red-green colorblind</p> <p>0%</p>



3. The bison herd on Konza Prairie has begun to show a genetic defect. Some of the males have a condition known as "rabbit hock" in which the knee of the back leg is malformed slightly. We do not yet know the genes controlling this trait but for the sake of our question, we shall assume it is an x-linked gene and that it is recessive. Now, suppose that the herd bull (the dominant one which does most of the breeding) who is normal mates with a cow that is a carrier for rabbit hock. What is the probability that a normal male offspring will be produced?

<p>Key</p> <p><math>X^H X^-</math> - normal ♀</p> <p><math>X^h X^h</math> - rabbit hock ♀</p> <p><math>X^H Y</math> - normal ♂</p> <p><math>X^h Y</math> - rabbit hock ♂</p>	<p>Parental genotypes</p> <p>♂ <math>X^H Y</math></p> <p>♀ <math>X^H X^h</math></p>	<p>Parental gametes</p> <p>♂ <math>X^H</math> <math>Y</math></p> <p>♀ <math>X^H</math> <math>X^h</math></p>
<p>Cross</p> <p><math>X^H</math> <math>X^h</math></p> <p><math>X^H</math> <math>X^H</math> <math>X^H X^h</math></p> <p><math>Y</math> <math>X^H Y</math> <math>X^h Y</math></p>	<p>Probability for a normal male offspring</p> <p>50% of males will be normal</p>	

4. A rancher owns a bull with many desirable characteristics. Unfortunately, he also has a x-linked trait that in the recessive form leads to no pigment formation in the iris of the eye. This makes the bull very sensitive to sunlight and could lead to blindness. The rancher wishes to breed him to a cow that will minimize the chances of any offspring showing this trait. She would especially like to produce another bull with most of his sire's desirable qualities but without the non-pigmented eye. Two cows with the dominant normal colored eyes are available that have been genetically typed for this particular trait. Cow 1 has a homozygous normal genotype of and cow 2 is a carrier. Which of these two cows should the rancher choose as a mate to her bull if she wishes to minimize the occurrence of the non-pigmented eye in his offspring?

<p>Key</p> <p><math>X^B X^-</math> - normal ♀</p> <p><math>X^b X^b</math> - no pigment ♀</p> <p><math>X^B Y</math> - normal ♂</p> <p><math>X^b Y</math> - no pigment ♂</p>	<p>Parental genotypes (show with chromosomes)</p> <p>Bull <math>X^b Y</math></p> <p>Cow 1 <math>X^B X^B</math></p> <p>Cow 2 <math>X^B X^b</math></p>	<p>Parental gametes (show with chromosomes)</p> <p>Bull <math>X^b</math> <math>Y</math></p> <p>Cow 1 <math>X^B</math></p> <p>Cow 2 <math>X^B</math> <math>X^b</math></p>
<p>Cross 1</p> <p><math>X^b</math> <math>Y</math></p> <p><math>X^B</math> <math>X^B X^b</math> <math>X^B Y</math></p>	<p>Cross 2</p> <p><math>X^b</math> <math>Y</math></p> <p><math>X^B</math> <math>X^B X^b</math> <math>X^B Y</math></p> <p><math>X^b</math> <math>X^b X^b</math> <math>X^b Y</math></p>	<p>Which cow should be chosen?</p> <p>Cow 1</p>

What percentage of the male offspring from the preferred cross will have non-pigmented eyes? 0%

Will crossing the bull with this cow eliminate the trait from the herd? No If not, why not? (Use CER format)

Even though there are no cows displaying the trait from this cross, the females will all carry the trait. If the carriers mate, they can pass the trait on to their offspring.

5. Clouded leopards are a medium sized, endangered species of cat, living in the very wet cloud forests of Central America. Assume that the normal spots are a dominant, x-linked trait and that dark spots are the recessive counterpart. Suppose as a conservation biologist, you are involved in a clouded leopard breeding program. One year you cross a male with dark spots and a female with normal spots. She has four cubs and (conveniently for the purposes of our problem) two are male and two female. One each of the male and female cubs has normal spots and one each has dark spots. What is the genotype of the mother?

<p>Key</p> <p><math>X^N X^-</math> - normal spot ♀</p> <p><math>X^n X^n</math> - dark spot ♀</p> <p><math>X^N Y</math> - normal spot ♂</p> <p><math>X^n Y</math> - dark spot ♂</p>	<p>Genotype of male</p> <p><math>X^n Y</math></p>	<p>Genotypes of cubs</p> <p><math>X^N X^N</math>   <math>X^N Y</math></p> <p><math>X^n X^n</math>   <math>X^n Y</math></p>	<p>Genotype of female</p> <p><math>X^N X^n</math></p> <p>mom must be heterozygous to have any dark spot ♂ or ♀ cubs</p>
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Suppose a few years later, that you cross the female cub that has normal spots with a male that also has normal spots. What percentage of each genotype will be found in the cubs?

<p>Genotype of female</p> <p><math>X^N X^n</math></p> <p>Possible Gametes</p> <p><math>X^N</math>   <math>X^n</math></p>	<p>Genotype of Male</p> <p><math>X^N Y</math></p> <p>Possible Gametes</p> <p><math>X^N</math>   <math>Y</math></p>	<p>Cross</p> <p><math>X^N</math>   <math>X^N</math>   <math>X^n</math></p> <p><math>X^N</math>   <math>X^N X^N</math>   <math>X^N X^n</math></p> <p><math>Y</math>   <math>X^N Y</math>   <math>X^n Y</math></p>	<p>Probability of each possible genotype</p> <p>100 ♀ normal spots</p> <p>50% ♂ normal spots</p> <p>50% ♂ dark spots</p>
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Will any of the cubs from this latest cross have dark spots? yes

If so, what percentage and of what sex will they be? 50% of males