Codominance Worksheet (Blood types)

Human blood types are determined by genes that follow the CODOMINANCE pattern of inheritance. There are two dominant alleles (A & B) and one recessive allele (O).

<table>
<thead>
<tr>
<th>Blood Type (Phenotype)</th>
<th>Genotype</th>
<th>Can donate blood to:</th>
<th>Can receive blood from:</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>ii (OO)</td>
<td>A,B,AB and O (universal donor)</td>
<td></td>
</tr>
<tr>
<td>AB</td>
<td>IAIB</td>
<td>AB</td>
<td>A,B,AB,AB and O (universal donor)</td>
</tr>
<tr>
<td>A</td>
<td>IAIA or IAi (IAO)</td>
<td>AB, A</td>
<td>O,A</td>
</tr>
<tr>
<td>B</td>
<td>IBIB or IBi (IBO)</td>
<td>AB,B</td>
<td>O,B</td>
</tr>
</tbody>
</table>

1. Write the genotype for each person based on the description:
   a. Homozygous for the “B” allele
   b. Heterozygous for the “A” allele
   c. Type O
   d. Type “A” and had a type “O” parent
   e. Type “AB”
   f. Blood can be donated to anybody
   g. Can only get blood from a type “O” donor

2. Pretend that Brad Pitt is homozygous for the type B allele, and Angelina Jolie is type “O.” What are all the possible blood types of their baby? (Do the punnett square)

3. Complete the punnett square showing all the possible blood types for the offspring produced by a type “O” mother and an A “AB” father. What are percentages of each offspring?

4. Mrs. Essy is type “A” and Mr. Essy is type “O.” They have three children named Matthew, Mark, and Luke. Mark is type “O,” Matthew is type “A,” and Luke is type “AB.” Based on this information:
   a. Mr. Essy must have the genotype QQ because Mark has blood type Q.
   b. Mrs. Essy must have the genotype AB because Matt has blood type AB.
   c. Luke cannot be the child of these parents because neither parent has the allele B.

5. Two parents think their baby was switched at the hospital. Its 1968, so DNA fingerprinting technology does not exist yet. The mother has blood type “O,” the father has blood type “AB,” and the baby has blood type “B.”
   a. Mother’s genotype: QQ
   b. Father’s genotype: IAIB or IBIB
   c. Baby’s genotype: AB or BB
   d. Punnett square showing all possible genotypes for children produced by this couple.
   e. Was the baby switched? NO
BLOOD TYPE & INHERITANCE

In blood typing, the gene for type A and the gene for type B are codominant. The gene for type O is recessive. Using Punnett squares, determine the possible blood types of the offspring when:

1. Father is type O, Mother is type O

\[
\begin{array}{c|c|c}
& O & O \\
\hline
O & O & O \\
0 & 0 & 0 \\
\hline
0 & 0 & 0 \\
\end{array}
\]

100% O  0% A  0% B  0% AB

2. Father is type A, homozygous; Mother is type B, homozygous

\[
\begin{array}{c|c|c}
A & A & \\
\hline
B & AB & AB \\
B & AB & AB \\
\end{array}
\]

100% O  0% A  0% B  100% AB

3. Father is type A, heterozygous; Mother is type B, heterozygous

\[
\begin{array}{c|c|c|c}
A & O & \\
\hline
B & AB & BO \\
0 & AO & OO \\
\end{array}
\]

25% O  25% A  25% B  25% AB

4. Father is type O, Mother is type AB

\[
\begin{array}{c|c|c}
O & O & \\
\hline
A & AO & AO \\
B & BO & BO \\
\end{array}
\]

25% O  50% A  25% B  0% AB

5. Father and Mother are both type AB

\[
\begin{array}{c|c|c}
A & B & \\
\hline
A & AA & AB \\
B & AB & BB \\
\end{array}
\]

0% O  25% A  25% B  50% AB
Practice: Codominance and Incomplete Dominance - KEY

1. Practice setting up keys for the phenotypes listed in each set. Remember that the "medium" trait must always be heterozygous.

   a) Birds can be blue, white, or white with blue-tipped feathers.
   
   \[BB = \text{blue}, \; BW = \text{blue tips}, \; WW = \text{white}\]
   
   OR you can use other way to set up problems using a single letter
   
   \[BB = \text{blue}, \; Bb = \text{tips}, \; bb = \text{white}\]

   b) Flowers can be white, pink, or red. \(RR = \text{red}, \; RW = \text{pink}, \; WW=\text{white}\)

   c) A Hoo can have curly hair, spiked hair, or a mix of both curly and spiked. \(CC = \text{curly}, \; CS = \text{mixed}, \; SS = \text{spiked}\)

   d) A Sneech can be tall, medium, or short. \(TT=\text{tall}, \; TS = \text{medium}, \; SS = \text{short}\)

   e) A Bleexo can be spotted, black, or white. \(BB = \text{black}, \; BW = \text{spotted}, \; WW = \text{white}\)

2. Now, can you figure out in the above list, which of the letters represent codominant traits and which are incomplete.

   if it "BLENDS" then it is incomplete dominance, if both traits are expressed, it is codominant. Students can become overly anxious about this difference, when in fact the problem solving is no different and the difference is largely a matter of semantics.

   Codominant ___a, c, e____________ Incompletely Dominant _____b, d_________

3. In Smileys, eye shape can be starred, circular, or a circle with a star. Write the genotypes for the pictured phenotypes

   \[\bigcirc \bigstar \bigcirc \] SS = star, SC = circle-star, CC = circle

4. Show the cross between a star-eyed and a circle eyed. SS x CC

   What are the phenotypes of the offspring? ____all star circle____

   What are the genotypes? ____SC____
Simple Genetics Practice Problems (10 points)

1. For each genotype, indicate whether it is heterozygous (HE) or homozygous (HO)

<table>
<thead>
<tr>
<th>AA</th>
<th>Ee</th>
<th>li</th>
<th>Mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>HO</td>
<td>HE</td>
<td>He</td>
<td>HE</td>
</tr>
<tr>
<td>Bb</td>
<td>FF</td>
<td>Jj</td>
<td>nn</td>
</tr>
<tr>
<td>Cc</td>
<td>GG</td>
<td>kk</td>
<td>OO</td>
</tr>
<tr>
<td>Dd</td>
<td>HH</td>
<td>LL</td>
<td>PP</td>
</tr>
</tbody>
</table>

2. For each of the genotypes below, determine the phenotype.

<table>
<thead>
<tr>
<th>Purple flowers are dominant to white flowers</th>
<th>Brown eyes are dominant to blue eyes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PP Purple</td>
<td>BB Brown</td>
</tr>
<tr>
<td>Pp Purple</td>
<td>Bb Brown</td>
</tr>
<tr>
<td>Pp white</td>
<td>bb blue</td>
</tr>
<tr>
<td>Round seeds are dominant to wrinkled</td>
<td>Boxtails are recessive (long tails dominant)</td>
</tr>
<tr>
<td>RR Round</td>
<td>TT Box long</td>
</tr>
<tr>
<td>Rr Round</td>
<td>Tt Box long</td>
</tr>
<tr>
<td>rr wrinkled</td>
<td>tt Box long</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. For each phenotype, list the genotypes. (Remember to use the letter of the dominant trait)

<table>
<thead>
<tr>
<th>Straight hair is dominant to curly.</th>
<th>Pointed heads are dominant to round heads.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA straight</td>
<td>TT pointed</td>
</tr>
<tr>
<td>aa curly</td>
<td>Tt pointed</td>
</tr>
</tbody>
</table>

4. Set up the square for each of the crosses listed below. The trait being studied is round seeds (dominant) and wrinkled seeds (recessive)

\[
\begin{array}{c|c|c}
Rr & Rr & Rr \\
\hline
r & Rr & rr \\
\hline
v & Rr & rr \\
\end{array}
\]

What percentage of the offspring will be round? \(50\%\)
**Rr x Rr**

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>RR</td>
<td>Rr</td>
</tr>
<tr>
<td>r</td>
<td>Rr</td>
<td>rr</td>
</tr>
</tbody>
</table>

What percentage of the offspring will be round? **75%**

**RR x Rr**

<table>
<thead>
<tr>
<th></th>
<th>R</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>RR</td>
<td>RR</td>
</tr>
<tr>
<td>r</td>
<td>Rr</td>
<td>rr</td>
</tr>
</tbody>
</table>

What percentage of the offspring will be round? **100%**

**Practice with Crosses. Show all work!**

5. A TT (tall) plant is crossed with a tt (short plant).
   What percentage of the offspring will be tall? **100%**

6. A Tt plant is crossed with a Tt plant.
   What percentage of the offspring will be short? **25%**

7. A heterozygous round seeded plant (Rr) is crossed with a homozygous round seeded plant (RR).
   What percentage of the offspring will be homozygous (RR)? **50%**

8. A homozygous round seeded plant is crossed with a homozygous wrinkled seeded plant. What are the genotypes of the parents? **RR x rr**
   What percentage of the offspring will also be homozygous? **0%**

9. In pea plants, purple flowers are dominant to white flowers. If two white flowered plants are crossed, what percentage of their offspring will be white flowered? **100%**
10. A white flowered plant is crossed with a plant that is heterozygous for the trait. What percentage of the offspring will have purple flowers? 60%

11. Two plants, both heterozygous for the gene that controls flower color are crossed. What percentage of their offspring will have purple flowers? 50%
What percentage will have white flowers? 25%

12. In guinea pigs, the allele for short hair is dominant. What genotype would a heterozygous short haired guinea pig have? Aa
What genotype would a purebreeding short haired guinea pig have? AA
What genotype would a long haired guinea pig have? aa

13. Show the cross for a pure breeding short haired guinea pig and a long haired guinea pig. What percentage of the offspring will have short hair? 100%

14. Show the cross for two heterozygous guinea pigs. What percentage of the offspring will have short hair? 75%
What percentage of the offspring will have long hair? 25%

15. Two short haired guinea pigs are mated several times. Out of 100 offspring, 25 of them have long hair. What are the probable genotypes of the parents? Aa x Aa Show the cross to prove it!
Genetics - X Linked Genes

**In fruit flies, eye color is a sex linked trait. Red is dominant to white.**

1. What are the sexes and eye colors of flies with the following genotypes?
   - $X^r X^r$ F; red
   - $X^r Y$ M; red
   - $X^{r'} X^r$ F; white
   - $X^{r'} Y$ M; white

2. What are the genotypes of these flies:
   - White eyed, male $X^r Y$
   - Red eyed, female $X^r X^r$
   - Red eyed, male $X^r Y$

3. Show the cross of a white eyed female $X^r X^r$ with a red-eyed male $X^r Y$.

   

4. Show a cross between a pure red eyed female and a white eyed male.

   - What are the genotypes of the parents:
     - $X^r X^r$
     - $X^r Y$

   - How many are:
     - White eyed, male 0/1.
     - White eyed, female 0/1.
     - Red eyed, male 1/1.
     - Red eyed, female 0/1.

5. Show the cross of a red eyed female (heterozygous) and a red eyed male.

   - What are the genotypes of the parents?
     - $X^r X^r$
     - $X^r Y$

   - How many are:
     - White eyed, male 25/1.
     - White eyed, female 0/1.
     - Red eyed, male 25/1.
     - Red eyed, female 0/1.
Human Sex Linkage

6. In humans, hemophilia is a sex linked trait. Females can be normal, carriers, or have the disease. Males will either have the disease or not (but they won’t ever be carriers).

\[
\begin{align*}
X^H X^H &= \text{female, normal} \\
X^H X^h &= \text{female, carrier} \\
X^h X^h &= \text{female, hemophiliac} \\
X^H Y &= \text{male, normal} \\
X^h Y &= \text{male, hemophiliac}
\end{align*}
\]

Show the cross of a man who has hemophilia with a woman who is a carrier.

What is the probability that their children will have the disease? 50%.

7. A woman who is a carrier marries a normal man. Show the cross. What is the probability that their children will have hemophilia? What sex will a child in the family with hemophilia be?

8. A woman who has hemophilia marries a normal man. How many of their children will have hemophilia, and what is their sex?

\[
\begin{align*}
X^H X^h \\
X^H Y \\
X^h Y
\end{align*}
\]

25% chance male

\[
\begin{align*}
X^h X^h \\
X^h Y \\
Y
\end{align*}
\]

50% chance male
Worksheet: Dihybrid Crosses

UNIT 3: GENETICS
STEP 1: Determine what kind of problem you are trying to solve.
STEP 2: Determine letters you will use to specify traits.
STEP 3: Determine parent’s genotypes.
STEP 4: Make your punnett square and make gametes
STEP 5: Complete cross and determine possible offspring.
STEP 6: Determine genotypic and phenotypic ratios.
Two-Factor Crosses (Di-hybrid)

Ex) A tall green pea plant (TTGG) is crossed with a short white pea plant (ttgg).

<table>
<thead>
<tr>
<th>TT or Tt = tall</th>
<th>tt = short</th>
<th>GG or Gg = green</th>
<th>gg = white</th>
</tr>
</thead>
<tbody>
<tr>
<td>TG</td>
<td>TG</td>
<td>TG</td>
<td>TG</td>
</tr>
<tr>
<td>tG</td>
<td>TtGg</td>
<td>TtGg</td>
<td>TtGg</td>
</tr>
<tr>
<td>tG</td>
<td>TtGg</td>
<td>TtGg</td>
<td>TtGg</td>
</tr>
<tr>
<td>tG</td>
<td>TtGg</td>
<td>TtGg</td>
<td>TtGg</td>
</tr>
<tr>
<td>tG</td>
<td>TtGg</td>
<td>TtGg</td>
<td>TtGg</td>
</tr>
</tbody>
</table>

16 Tall/Green : 0 Tall/White : 0 Short/Green : 0 Short/White

1) A tall green pea plant (TTGg) is crossed with a tall green pea plant (TtGg)

\[
\text{TtGg} \times \text{TtGg}
\]

<table>
<thead>
<tr>
<th>TG</th>
<th>TG</th>
<th>TG</th>
</tr>
</thead>
<tbody>
<tr>
<td>TTGG</td>
<td>TTGG</td>
<td>TTGG</td>
</tr>
<tr>
<td>TTGG</td>
<td>TTGG</td>
<td>TTGG</td>
</tr>
<tr>
<td>TTGG</td>
<td>TTGG</td>
<td>TTGG</td>
</tr>
</tbody>
</table>

\[
\frac{15}{12:4:0:0}\text{ Tall/Green : 2S/Tall/White : 0/Short/Green : 0/Short/White}
\]

12 4 0 0
2) A tall green pea plant (TtGg) is crossed with a Short white pea plant (ttgg).

\[
\begin{array}{c|c|c|c|c}
 & Tg & Tg & tA & tG \\
\hline
Tg & TtGg & TtGg & ttGg & ttGg \\
Tg & TtGg & TtGg & ttGg & ttGg \\
Tg & TtGg & TtGg & ttGg & ttGg \\
Tg & TtGg & TtGg & ttGg & ttGg \\
\end{array}
\]

\[
\frac{25\%}{\text{Tall/Green}} : \frac{25\%}{\text{Tall/White}} : \frac{25\%}{\text{Short/Green}} : \frac{25\%}{\text{Short/White}} = 4 : 4 : 4 : 4
\]

3) A Homozygous tall, green flowered plant is crossed with a Homozygous short white flowered plant.

\[
\begin{array}{c|c|c|c|c}
 & Tg & Tg & Tg & tG \\
\hline
Tg & TtGg & TtGg & TtGg & TtGg \\
Tg & TtGg & TtGg & TtGg & TtGg \\
Tg & TtGg & TtGg & TtGg & TtGg \\
Tg & TtGg & TtGg & TtGg & TtGg \\
\end{array}
\]

\[
\frac{100\%}{\text{Tall/green}} : \frac{0\%}{\text{Tall/White}} : \frac{0\%}{\text{Short/green}} : \frac{0\%}{\text{Short/White}} = 16 : 0 : 0 : 0
\]
4) Two Heterozygous Tall, Green pea plants are crossed.

\[ TtGg \times TtGg \]

\[
\begin{array}{c|cccc}
Tg & Tg & Tg & Tg & Tg \\
TG & TtGg & TtGg & TtGg & TtGg \\
Tg & TtGg & TtGg & TtGg & TtGg \\
tG & TtGg & TtGg & TtGg & TtGg \\
tg & TtGg & TtGg & TtGg & TtGg \\
\end{array}
\]

\[
\frac{9}{16} \text{Tall/Green} : \frac{3}{16} \text{Tall/White} : \frac{3}{16} \text{Short/Green} : \frac{1}{16} \text{Short/White}
\]

1. In man, assume that spotted skin (S) is dominant over non-spotted skin (s) and that wooly hair (W) is dominant over non-wooly hair (w). Cross a marriage between a heterozygous spotted, non-wooly man with a heterozygous wooly-haired, non-spotted woman. Give genotypic and phenotypic ratios of offspring.

\[
Ssww \times ssWw
\]

\[
\begin{array}{c|c|c|c|c}
Sw & Sw & sw & sw \\
Sw & Sw & Sw & Sw \\
Ssww & Ssww & Ssww & Ssww \\
SsWw & SsWw & SsWw & SsWw \\
\end{array}
\]

25% (4/16) spotted, sw

25% (4/16) non-spotted, sw

25% (4/16) spotted, non-wooly

25% (4/16) non-spotted, non-wooly

2. In horses, black is dependent upon a dominant gene, B, and chestnut upon its recessive allele, b. The trotting gait is due to a dominant gene, T, the pacing gait to its recessive allele, t. If a homozygous black pacer is mated to a homozygous chestnut trotter, what will be the appearance of the F\(_1\) generation?

\[
BBTT \times bbtt
\]

\[
\begin{array}{c|c|c|c|c}
BT & BT & BT & BT \\
BbTt & BbTt & BbTt & BbTt \\
Bbt & Bbt & Bbt & Bbt \\
Btt & Btt & Btt & Btt \\
\end{array}
\]

100% Black trotters
3. 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). If a squash plant true-breeding for white, disk-shaped fruit is crossed with a plant true-breeding for yellow, sphere-shaped fruit:

```
<table>
<thead>
<tr>
<th>WWDDx</th>
<th>wD/WD</th>
<th>WWDD</th>
<th>WuDd</th>
<th>WuDd</th>
<th>WuDd</th>
<th>WuDd</th>
</tr>
</thead>
<tbody>
<tr>
<td>wD/WD</td>
<td>WD/WD</td>
<td>WD/WD</td>
<td>WD/WD</td>
<td>WD/WD</td>
<td>WD/WD</td>
<td>WD/WD</td>
</tr>
<tr>
<td>wD/wD</td>
<td>WD/WD</td>
<td>WD/WD</td>
<td>WD/WD</td>
<td>WD/WD</td>
<td>WD/WD</td>
<td>WD/WD</td>
</tr>
<tr>
<td>wD/wD</td>
<td>WD/WD</td>
<td>WD/WD</td>
<td>WD/WD</td>
<td>WD/WD</td>
<td>WD/WD</td>
<td>WD/WD</td>
</tr>
</tbody>
</table>
```

5. In mice, the ability to run normally is a dominant trait. Mice with this trait are called running mice (R). The recessive trait causes mice to run in circles only. Mice with this trait are called waltzing mice (r). Hair color is also inherited in mice. Black hair (B) is dominant over brown hair (b). For each of the following problems, determine the parent genotypes, determine possible gametes, then construct a Punnet square to solve.

**a.** Cross a heterozygous running, heterozygous black mouse with a homozygous running, homozygous black mouse:

Parental genotypes: $RrBB \times RRBB$

Possible gametes: $Rr, Rr, BB, BB, RB, RB$

Offspring phenotypic ratio:

```
<table>
<thead>
<tr>
<th>100% Running/Black</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB, BB, BB, BB, BB, BB</td>
</tr>
</tbody>
</table>
```

**b.** Cross a homozygous running, homozygous black mouse with a heterozygous running, brown mouse:

Parental genotypes: $RRBB \times RrBb$

Possible gametes: $RB, RB, Bb, Bb, RB, RB$

Offspring phenotypic ratio:

```
<table>
<thead>
<tr>
<th>100% Running/Black</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB, BB, BB, BB, RB, RB</td>
</tr>
</tbody>
</table>
```

**c.** Cross a waltzing brown mouse with a waltzing brown mouse
d. Cross a homozygous running, heterozygous black mouse with a waitzing brown mouse

Parental genotypes \( BBbb \times rrBB \)
Possible gametes __________ → __________
Offspring phenotypic ratio __________

50% Running/Black
50% Running/Brown

---

e. Cross a heterozygous running, brown mouse with a heterozygous running, homozygous black mouse

Parental genotypes \( RrBB \times Rrbb \)
Possible gametes __________ → __________
Offspring phenotypic ratio __________

100% Running Black

---

f. Cross a heterozygous running, heterozygous black mouse with a heterozygous running, heterozygous black mouse

Parental genotypes \( RrBB \times Rrbb \)
Possible gametes __________ → __________
Offspring phenotypic ratio __________

9 Running/Black
3 Running/ Brown
3 Black Waltzing/ Black
1 Waltzing/ Brown