Genetics Worksheet

Part 1 Introduction:

1.   Describe the genotypes given (use your notes). The first two are already done.

      A.   DD *homozygous, dominant*   D. ss _____

      B.   Dd *heterozygous*_____   E. Yy _____

      C.   dd _____   F. WW _____

2.   In humans, brown eye color (B), is dominant over blue eye color (b). What are the **phenotypes** of the following genotypes? In other words, what color eyes will they have?

      A.   BB _____

      B.   bb _____

      C.   Bb _____

The Five (5) Steps Associated With Solving a Genetics Problem:

If you take the time to follow the directions below, you will be able to solve most genetics problems.

    1.   **Determine** the **genotypes** of the parents or whatever is given in problem.

    2.   Set up your **Punnett square** as follows: *# sq. based on possible gametes that can be formed.
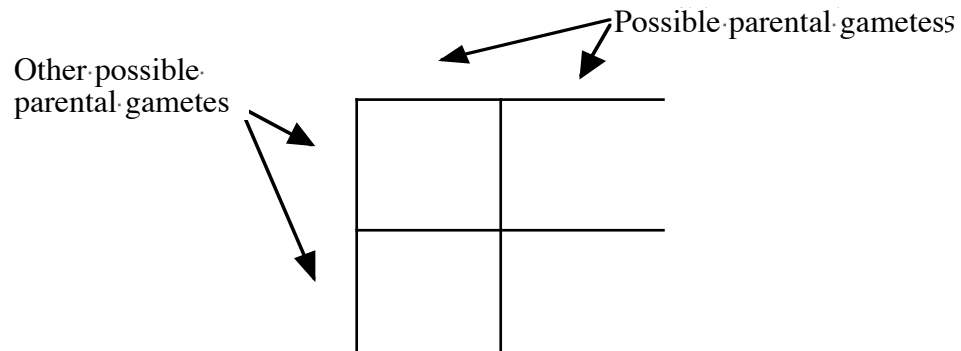
    3.   **Fill in** the squares. This represents the possible combinations that could occur during fertilization.

    4.   **Write out** the possible **genotypic ratio** of the offspring.

    5.   **Using** the **genotypic** ratio determine the phenotypic ratio for the offspring.

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Part 2: Sample Problem (Just read this over, it is a practice problem)

A heterozygous male, black eyed mouse is crossed with a red eyed, female mouse. Predict the possible offspring!

Step 1: **Determine the genotype of the parents**. The male parent is **heterozygous** which means he has one allele for black eyes and one allele for red eyes. Since his eyes are black, this means that black allele must be dominant over the red allele. So the male parents genotype is "**Bb**" (B = allele for black eye, b = allele for red eye).

The female parent has red eyes, there is only one way to have this recessive phenotype, so she must to be homozygous recessive. Homozygous recessive means that her genotype must be "**bb**". Therefore, genotype of the parents is **Bb x bb.**

Step 2:

During meiosis (the formation of sex cells) one member (allele) of each gene pair separate. The male mouse (Bb) produces some sperm containing "B" (the allele for black eye) and some sperm containing "b" (the allele for red eyes).

On one axis of the Punnett square you put the two possible gametes for the male.

Possible
Sperm

B   b

b
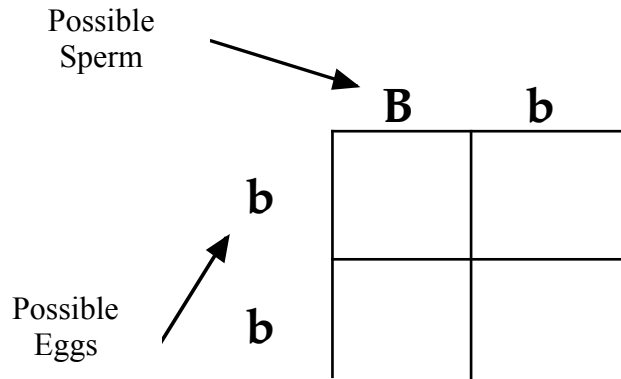
Possible
Eggs   b

Repeat this for the other axis for the possible female gametes. Since she is "bb" you must put "b" and "b".

Step 3:

During fertilization sperm meets the egg. The Punnett square show us the various **possibilities** during fertilization. The offspring must be one of these genotypes listed in the squares.

B   b

b   Bb

b
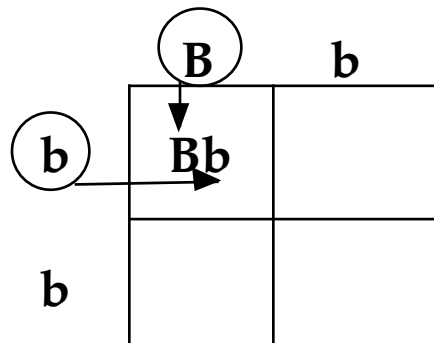
If the sperm contains a "B" and it fertilizes an egg containing the "b" allele, the resultant offspring will have the genotype "Bb".

Repeating the process we can see all of the possible genotypes.

B   b
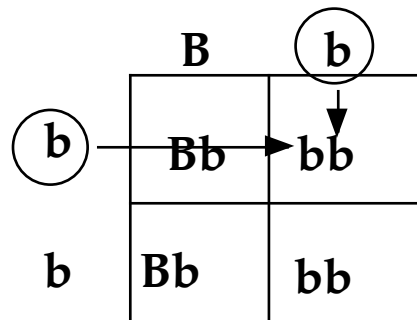
b   Bb   bb

b   Bb   bb

Step 4:

The genotypic ratio is determined by counting each possible genotype. You'll note there are two "Bb" for every two "bb". Therefore, we write the ratio as   **2 : 2**
                                                                                                                                                Bb : bb

Normally we reduce to the lowest terms: 1 :   1
                                                 Bb : bb

Step 5:

The Bb will produce a black eyed mouse (phenotype) and the bb will produce a red eyed mouse (phenotype). The phenotypic ratio is written as   1   :   1
                                                                                                                                           black eye : red eye

*Ratios tell you there is an **even chance** of having offspring with black eyes as there is for having offspring with red eyes. That would be the same as a 50% probability of having red eyes, or a 50% probability of having black eyes.*

. ****On the following pages are several problems. With each new problem, one sample is illustrated, <u>make sure you look over the sample.</u>** In your **spiral** *notebook* you **must** copy the first problem from each section along with its solution. This means you should have a total of **eight** problems **written** out and **<u>solved</u>**: **monohybrid cross**, **working backwards**, **test (back) cross**, **dihybrid cross**, **incomplete dominance**, **multiple alleles**, **sex-linked cross** and **pedigree analysis**.

Part 3 Monohybrid Cross

When we study the inheritance of a single gene it is called a monohybrid cross. ****On the following pages are several problems.**

1. A heterozygous, smooth pea pod, plant is crossed with a wrinkled pea pod plant. *There are two alleles for pea pod, smooth and wrinkled.* **Predict the offspring from this cross.**

      a.   What is the the genotype of the parents? _____

      b.   Set up a Punnett square with possible gametes.

      c.   Fill in the Punnett square for the resultant offspring.

      d.   What is the predicted genotypic ratio for the offspring ?_____

      e.   What is the predicted phenotypic ratio for the offspring ?_____

      f.   If this cross produced 50 seeds how many would you predict to have a wrinkled pod?

2. In humans, acondroplasia "dwarfism" (D) is dominant over normal (d). A homozygous dominant (DD) person dies before the age of one. A heterozygous (Dd) person is dwarfed. A homozygous recessive individual is normal. A heterozygous dwarf man marries a dwarf heterozygous woman……..

    a.   What is the probability of having a normal child? _____

    b.   What is the probability that the next child will **<u>also</u>** be normal? _____

    b.   What is the probability of having a child that is a dwarf? _____

    b.   What is the probability of having a child that dies at one from this disorder? _____

3. In humans, free earlobes (F) is dominant over attached earlobes (f). If one parent is homozygous dominant for free earlobes, while the other has attached earlobes can they produce any children with attached earlobes?

4. In humans widow's peak (W) is dominant over straight hairline (w). A heterozygous man for this trait marries a woman who is also heterozygous.

    a. List possible genotypes of their offspring.

    a. List the phenotypic ratio for their children.

Part 4: Working Backwards

Some times we only know about the offspring and we want to learn about the parents. If you have been paying attention, you should have started to notice a pattern. For example, when both

parents are heterozygous the phenotypic ratio always comes out 3 to 1. If one parent is homozygous recessive and the other is heterozygous, the phenotypic ratio always comes out 1 to 1. Keeping this in mind see if you can solve the next two problems.

1. In pea plants, yellow seeds (Y) are dominant and green seeds (y) are recessive. A pea plant with yellow seeds is crossed with a pea plant with green seeds. The resulting offspring have about equal numbers of yellow and green seeded plants. What are the genotypes of the parents?

1. In another cross, a yellow seeded plant was crossed with another yellow seeded plant and it produced offspring of which about 25% were green seeded plants.
   What are the genotypes of both parents?

Part 5: Back Cross/Test Cross

When an organism has the dominant phenotype, then its genotype can be either heterozygous or homozygous dominant (you can't tell by looking at it). In order to find out we must do a test cross using an homozygous, recessive organism. For example:

*In Dalmatian dogs, the gene for black spots is dominant to the gene for liver colored spots. If a breeder has a black spotted dog, how can she find out whether it is homozygous(BB) or heterozygous(Bb) spotted dog? *B = black spots and b = liver spots*

If the breeder finds a black spotted dog, whose ancestry is not known, she cannot tell by looking at the dog if it is BB or Bb. She should find a liver spotted dog, whose genotype must be "bb" and mate it with the black spotted dog in question.
This is the cross of a homozygous (BB) individual:

	B	**B**
b	Bb	Bb
b	Bb	Bb

Notice that all of the offspring will be Bb and therefore, there is no possibility of having an liver spotted offspring.

*This would be the resultant Punnett sq. for the heterozygous (Bb) individual.

	B	**b**
b	Bb	bb
b	Bb	bb

If any of the breed offspring has liver spots, then she can say that she had a heterozygous black spotted dog. If all the offspring had black spots then she can say that the suspect dog was homozygous.

1. You found a wild, black mouse. Explain how you would determine the genotype of this mouse. *Hint in mice, white fur is recessive.*

   a. Draw Punnett squares for your possible crosses.

   a. You have 24 offspring, 23 with black fur and 1 with white fur. What was the genotype of

   the mouse? _____

   a. If you only had 3 black offspring, can you tell what the genotype was of the suspect mouse? Explain why or why not.

Part 6: Dihybrid Cross

   When we study two traits on different chromosomes, at one time, we call this a dihybrid cross. You still follow the same five step process for Monohybrid crosses but now there will be four times as many possibilities because we are studying two traits.

E.g. **A female guinea pig is heterozygous for both fur color and coat texture is crossed with a male that has light fur color and is heterozygous for coat texture. What possible offspring can they produce?** *Dark fur color is dominant (D) and light fur (d) is recessive. Rough coat texture (R) is dominant, while smooth coat (r) is recessive.*

   Step 1: *The guinea pig that is heterozygous for both color and texture this means it has one allele for each trait. Therefore its genotype would be "DdRr". The other guinea pig has light fur, since that is a recessive trait the genotype for that trait must be "dd". It is also heterozygous for fur texture, which means a genotype of "Rr". All together its overall genotype must be "ddRr".*

   Step 2 and 3: *The Punnett square will be larger now because there are more possible sperm and egg combinations. During the formation of sperm a "D" could go with a "R" producing a sperm "DR", or a "D" could go with a "r" forming a sperm with "Dr".*
   Filling-in the Punnett square it should look like the one we started below . Finish off filling in the blank squares in the Punnett square.

	DR	D.r	dR	dr
d R	D,d R,R			
d.r		Ddrr	ddRr	
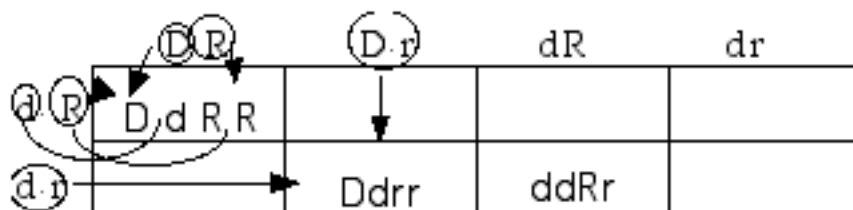
Step 4: After filling-in the Punnett square you should obtain the following genotypic ratio:
   *remember the numbers should add up to the number of squares filled in:
   4 DdRr : 2 DdRR : 4 ddRr : 2 ddRR : 2 Ddrr : 2 ddrr

Step 5: There will be only four different phenotypes because the 4 DdRr and the 2 DdRR will
   *have **dark** fur with **rough** coat, and the 4 with ddRr and the 2 ddRR will have **light** fur*
   *with **rough** coat, while the 2 Ddrr will have **dark** fur with **smooth** coat and the 2 ddrr will*
   *have **light** fur with **smooth** coat.*
   Therefore the phenotypic ratio would be:
   6 dark, rough : 6 light rough : 2 dark smooth : 2 light smooth.

1. In pea plants, the round seed allele is dominant over the wrinkled seed allele, and the yellow seed allele is dominant over the green seed allele. The genes for seed texture and those for seed color are on different chromosomes. A plant heterozygous for seed texture and seed color is crossed with a plant that is wrinkled and heterozygous for seed color. **R = round, r = wrinkled, Y= yellow, y = green*
   a.   Construct a Punnett square for this cross.

   b.   What is the expected **phenotypic** ratio for the offspring?

2. In humans there is a disease called Phenylketonuria (PKU)which is caused by a recessive allele. People with this allele have a defective enzyme and cannot break down the amino acid phenylalanine. This disease can result in mental retardation or death. Let "**E**" represent the normal enzyme. Also in humans in a condition called galactose intolerance or galactosemia, which is also caused by a recessive allele. Let "**G**" represent the normal allele for galactose digestion. In both diseases, normal dominates over recessive. If two adults were heterozygous for both traits (EeGg), what are the chances of having a child that is completely normal? Has just PKU? Has just galactosemia? Has both diseases?

Part 7: Incomplete Dominance or Codominance

In Four o'clock flowers the alleles for flower color are both equal therefore neither dominates over the other. We call this condition <u>incomplete</u> <u>dominance or codominance</u> and it violates Mendel's principle of dominance. A red four o'clock flower (rr) is crossed with a white flower (ww). Since there is no dominant trait we use two different little letters for the genotype.

Step 1: *The genotype of the red flower will be "rr" and the genotype of the white flower is "ww".*

Step 2 and 3: *Complete a Punnett square for this cross.*

	r	r
w	rw	rw
w	rw	rw

Step 4: *All of the offspring will be "rw". So the genotypic ratio is:*   **4 :   0 :   0**

                                                                rw   ww   rr

Step 5: *All of the offspring will have one of each allele (rw), so all will be pink.*

1. **Predict the offspring when two pink Four o'clock flowers are crossed.**
    a. Complete a Punnett square for this cross.

    b. What is the predicted genotypic ratio for the offspring?

    b. What is the predicted phenotypic ratio for the offspring?

2. In humans straight hair (ss) and curly hair (cc) are codominant traits, that result in hybrids who have wavy hair (sc). Cross a curly hair female with a wavy haired male.
    a.   Complete a Punnett square for this cross.

b.   What are the chances of having a curly haired child?

Part 8: Multiple Allele

So far we have studied traits or genes that are coded for by just two alleles. Like in rabbits, there was one allele for brown hair color and one allele for white hair. However, some traits are coded for by more than two alleles. One of these is blood type in humans. This is a violation of Mendel's Principle of unit characteristics.

*In humans, there are four types of blood; type A, type B, type AB, and type O. The alleles A and B are codominant to each other and the O allele is recessive to both A and B alleles. So a person with the genotype **AA** or **AO** will have **A type** of blood.*

a. What possible genotypes will produce B type of blood? _____

b. What is the only genotype that will produce O type of blood? _____

c. What is the only genotype that will produce AB type of blood? _____

1.   You are blood type O and you marry a person with blood type AB.
     a.   Complete a Punnett square for this cross.

      b.   List the possible blood types (phenotypes) of your offspring. _____

2.   In the 1950's, a young woman sued film star/director Charlie Chaplin for parental support of her illegitimate child. Charlie Chaplin's blood type was already on record as type AB. The mother of the child had type A and her son had type O blood.
     a.   Complete a Punnett square for the possible cross of Charlie and the mother.

b.	The judge ruled in favor of the mother and ordered Charlie Chaplin to pay child support costs of the child. Was the judge correct in his decision based on blood typing evidence? Explain why or why not. *refer to any Punnett squares to support your answer.*

3.	Suppose a newborn baby was accidentally mixed up in the hospital. In an effort to determine the parents of the baby, the blood types of the baby and two sets of parents were determined.

      Baby 1 had type O   Mrs. Brown had type B   Mr. Brown had type AB
                          Mrs. Smith had type B   Mr. Smith had type B

a.	Draw Punnett squares for each couple (you may need to do more than 1 square/ couple)

b.	To which parents does baby #1 belong? Why? *Hint you may want to refer to your Punnett squares.*

## Part 9	SEX LINKED TRAITS

*As many of you know boys are different than girls. In humans sex is determine by the twenty third pair of chromosomes known as "sex chromosomes". If you have two x-shaped (**XX**) chromosomes you are destined to be a female. If you have an x and a Y-shaped (**XY**) chromosomes you are destined to be a male. Since the **X** and **Y** chromosomes carry different information, any genes found on the **X** chromosomes are referred to as **sex-linked genes**. Therefore, women will have two alleles for these genes because they have two (**XX**) chromosomes. On the other hand, men have only one allele for each of these genes because they have only one X chromosome (**XY**). This is clearly a violation of Mendel's Principle of Unit Characteristics, which implies that you receive one set of alleles from each parent.*

E.g.	*In fruit flies, the gene for eye color is carried on the **X** chromosome which is a sex chromosome (sex-linked). The allele for red eyes is dominant over the allele for white eyes. **If a white-eyed female fruit fly is mated with a red-eyed male, predict the possible offspring.***

Step 1: *Since the female has white eyes, she must be "X^rX^r". The male is red-eyed and because he has only one X chromosome, he has only one allele for eye color. His eyes are red so he must be **RY**. means he only has one allele for eye color, so he must be "X^RY". Since the allele "R" is present on the X chromosome only, and there is no other allele for eye color because the male other sex chromosome is a Y chromosome.*

Step 2: *For sex-linked traits we need to list the genotype in a different fashion. We must identify the individual as being male or female according to their sex chromosomes. Females are XX, and males are XY. Sex-linked traits are only found on the X chromosome, therefore the letters are placed as superscripts (above) the X chromosome. Therefore the genotype for the female fly is*

X^rX^r and the male is X^RY. You can use shorthand notation rr x RY, but sometimes this can be confusing.

Step 3: *The Punnett square for the parent flies are shown below.*

	X^R	Y
X^r	X^RX^r	$X^r Y$
X^r	X^RX^r	$X^r Y$

Step 4: *The genotypic ratio is*   1 :   1
                       X^RX^r $X^r Y$

Step 5: *The individual* **$X^R X^r$** *will be a female because she has two* **X** *chromosomes.* *She will have red eyes because she has* Rr. *The individual with* **X^r Y** *will be a male because he has the* **X** *and* **Y** *chromosomes. He will have white eyes because he has only one allele and it is "r". So from this cross you would expect all of the females to have red eyes and all of the males to have white eyes.*

1. Hemophilia is a sex-linked trait. A person with hemophilia is lacking certain proteins that are necessary for normal blood clotting. Hemophilia is caused by a recessive allele so use "N" for normal and "n" for hemophilia. Since hemophilia is sex-linked, remember a woman will have two alleles (NN or Nn or nn) but a man will have only one allele (N or n). A woman who is heterozygous (a carrier) for hemophilia marries a normal man:

   a. What are the genotypes of the parents?

   b. Make a Punnett square for the above cross.

   c. What is the probability that a male offspring will have hemophilia? _____

   d. What is the probability of having a hemophiliac female offspring? _____

2. Can a color blind female have a son that has normal vision? Color blindness is caused by a sex-linked recessive allele. *use N = normal vision and n = color blind*

3. Baldness is a sex-linked trait. What parental genotypes could produce a bald woman? *use H = normal hair, and h = bald*
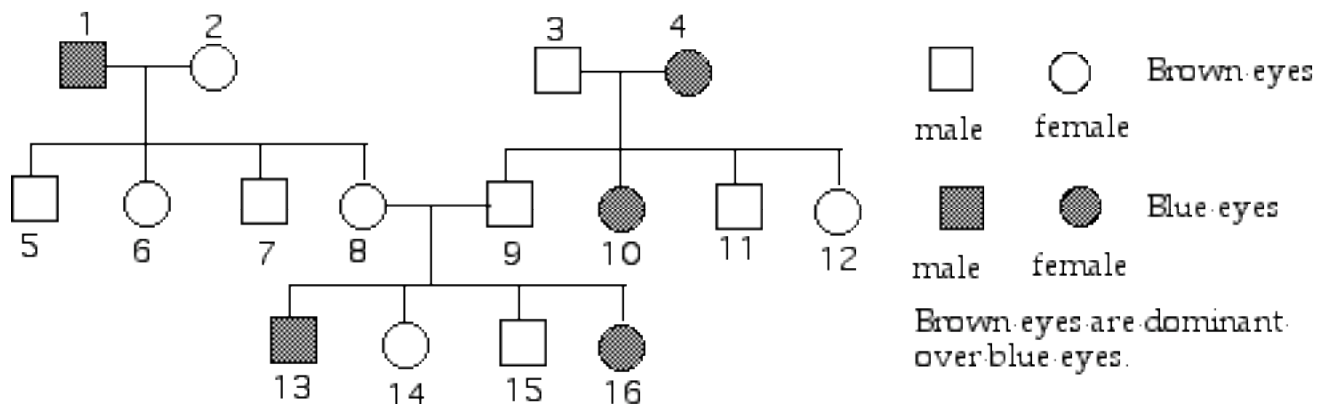
Part 10: Pedigree Charts:

In genetics, traits can be traced over several generations similar to a family tree. This family tree is called a Pedigree chart. Pedigree charts are useful in gathering background genetic information that can be used for medical reasons. Horse race enthusiasts also rely heavily on pedigree charts to predict a horse's success. sWhen interpreting pedigree charts remember square are male and circles are females

1. Use the below pedigree chart to answer the following three questions. Muscle type is not a sex linked characteristic.
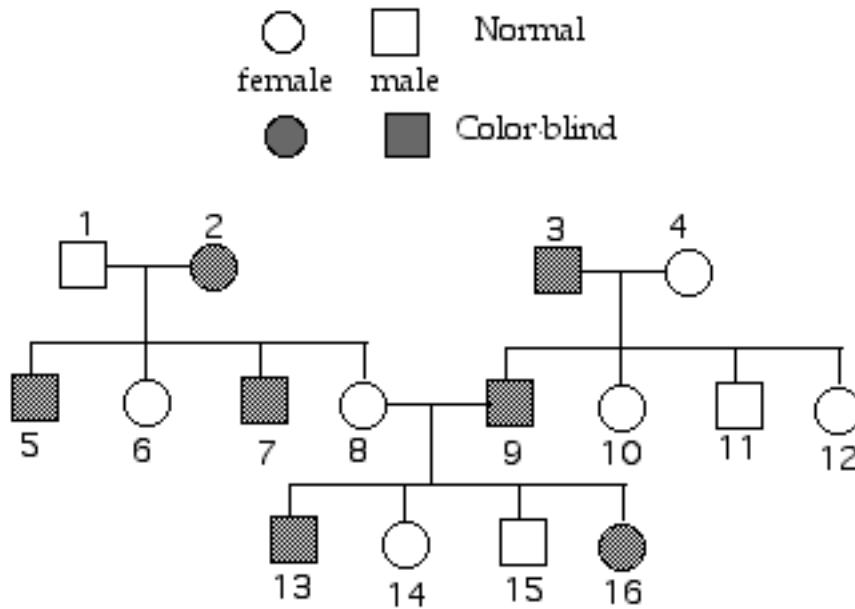

male   female

male   female

Fast-twitch-muscles dominate-over-slow twitch-muscles.
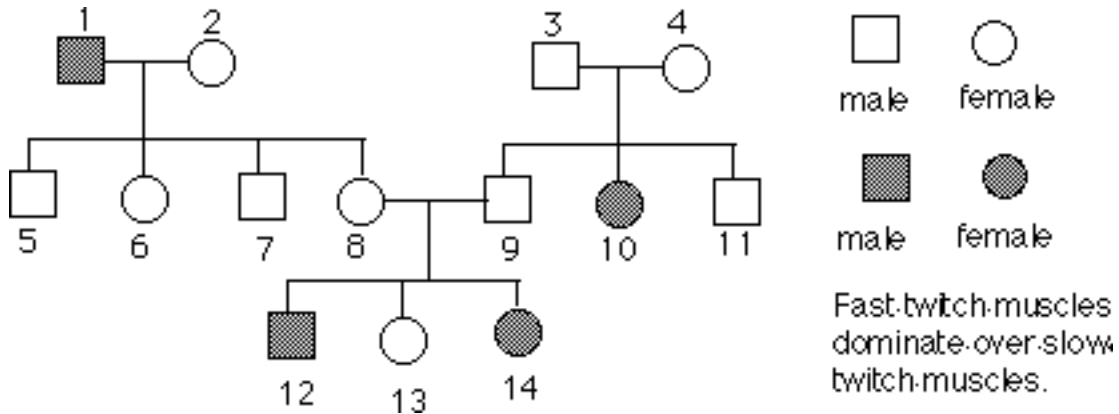
   a.   Place the genotypes of each individual below its symbol.

   b.   What is the genotype of individual #3 and 4?.

   c.   Can either individual #8 or 9 be homozygous?

   d.   Explain the family relationship that #12 has with #2.

2.   Label the genotype for each of the individuals below its symbol on the pedigree chart (note: eye color is **not** a sex-linked trait).

☐ ◯ Brown eyes
male   female

■ ● Blue eyes
male   female

Brown eyes are dominant over blue eyes.

3. List the possible genotypes of the following hemophilia pedigree chart below. **Remember hemophilia is a sex linked trait** that is caused by a **recessive allele,** therefore you must denote the individuals sex chromosomes ($X^N X^n$ and $X^n Y$ or Nn and nY) as well as the hemophilia allele (n).
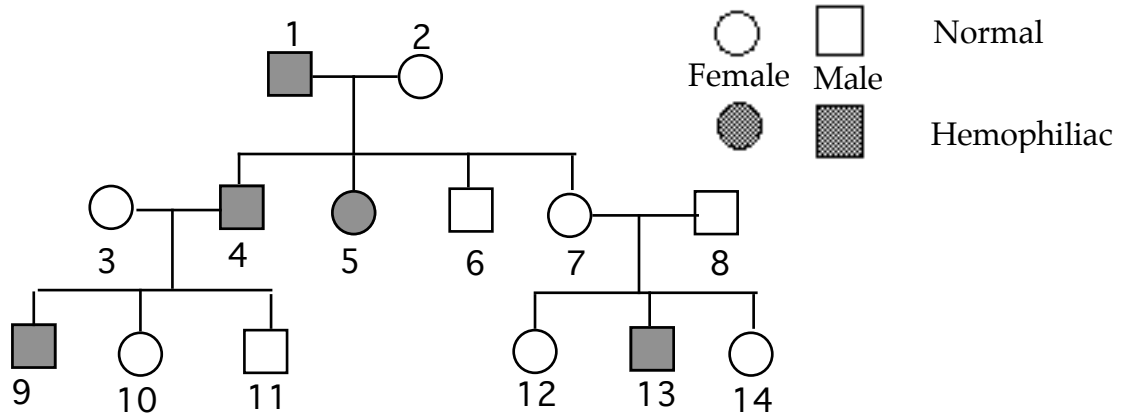
4. Examine the following pedigree chart of color-blindness. In humans, color blindness is caused by a **recessive sex-linked** allele. On the diagram, label the genotypes of the individuals 1-16.

5.   A blue-eyed man (1) whose parents were brown eyed (2 & 3), marries a brown eyed woman (4), whose father was brown eyed (5) and whose mother (6) was blue eyed. They have one female child who is blue eyed (7). Blue eyes are recessive.

   a.   Make a pedigree chart based on the above information.

   b.   Label the genotypes of the individuals in the chart.

Key

Part 1

  1.

       c.   Homozygous recessive

       d.   Homozygous recessive

       e.   Heterozygous

       f.   Homozygous dominant

  2.

       a.   Brown eyes

       b.   Blue eyes

       c.   Brown eyes

Part 3

  1

       a. Ss x ss

       b. Filled in Punnett Square

       c. Filled in Punnett Square

       d. 1 Ss : 1ss

       e. 1 smooth : 1 wrinkled

       f. 25

  2 Should have a filled in Punnett Square

    a. 25% or 1/4 or 1:3

    b. 25% or 1/4 or 1:3

    c. 50% or 1/2

    d. 25% or 1/4 or 1:3

  3 Should have a filled in Punnett Square and the answer is **<u>No</u>**

  4 Should have a filled in Punnett Square

    a. WW, Ww and ww

    b. 3 Widows Peak : 1 Straight

Part 4

  1. Yy x yy

  2 Yy x Yy

Part 5

  1a. **<u>2</u>** Punnentt squares should be filled in.

    b. Bb or heterozygous

    c. There were too few offspring to form a conclusion

Part 6.

  1.

    a. **Should have a filled in Punnett Square**

    b. Round Yellow : Round Green : Wrinkled Yellow : Wrinkled Green

    c.   **3**   **1**   **3**   **1**

  2 Should have a filled in Punnett Square

      Normal for both : Normal, Galactosemia : PKU; Normal : Have both disorders

            9   **3**   **3**   **1**

Part 7

  1.

  a. **Should have a filled in Punnett Square**

  b. 1 : 2 : 1

    rr rw ww

  c. . 1 : 2 : 1

red : pink : white
2.
3.
    a. **Should have a filled in Punnett Square**
    b. 50%
    c. CC

Part 8

    a. BB or BO
    b. OO
    c. AB

1.
    a. **Should have a filled in Punnett Square**
    b. Type A and Type B blood

2
a. **2 Punnentt squares should be drawn and filled in**
b. **No**

3.
a. **2 Punnentt squares should be drawn and filled in**

b. Mr. And Mrs. Smith

Part 9

1.
Nn x NY

    c. **Should have a filled in Punnett Square**
    d. **50%**
    e. **0%**
c. No
d. HY x Hh and hY x hh

Part 10

1.
  a.1. ff 2. **?** 3. **Ff** 4. **Ff** 5. **Ff** 6 **Ff** 7. **Ff**   8. **Ff** 9. **Ff** 10 **ff** 11 **?**   12. **ff** 13. **?**   14. **ff**
  b. **Ff and Ff**
  c. **No**
  d. **12 is** the grandson of 2

2.
 1. bb 2. ? 3. Bb 4. Bb 5. Bb 6. Bb 7. Bb 8. Bb 9. Bb 10. bb 11. ? 12. ? 13. bb 14. ? 15 ? 16. bb

3.

1. nY 2. Nn 3. Nn 4. nY 5. nn 6.NY 7. Nn 8. NY 9. nY 10. Nn 11. NY 12. ? 13. nY 14. ?

4.

1. NY 2. Nn 3. nY 4. Nn 5. NY 6 ? 7. nY 8. Nn 9. nY 10. Nn 11. NY 12. Nn 13. nY 14. Nn 15.

NY 16. nn