Rieder - Genetics
Worksheet 5
Due: 10/17/17 at the beginning of class

Name: ____

About how long did the individual portion of this homework take you? ____________________

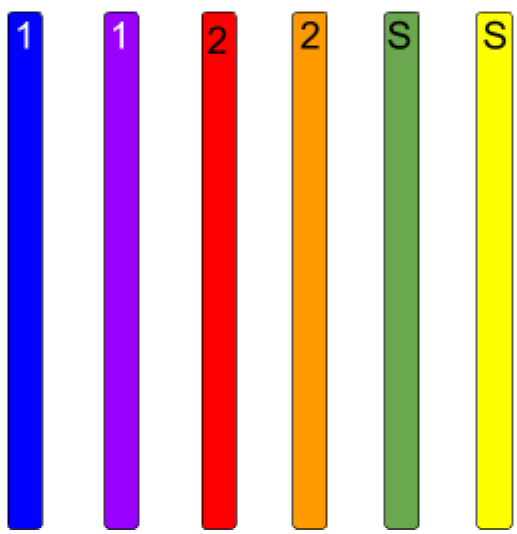
I consulted/worked with: ____

I will not accept late homework. Special exceptions will be made **only** in the event of illness or if you contact me at least 24 hours ahead of when the assignment is due (at my discretion).

POINTS: / 50

Please work in pairs for the in-class portion of this worksheet (in blue).

1. In front of each of you, arrange your six "chromosomes" to represent the **diploid genome** of a bird. This represents a **germ cell** that will soon make **gametes**. Arrange them **allele** side up.



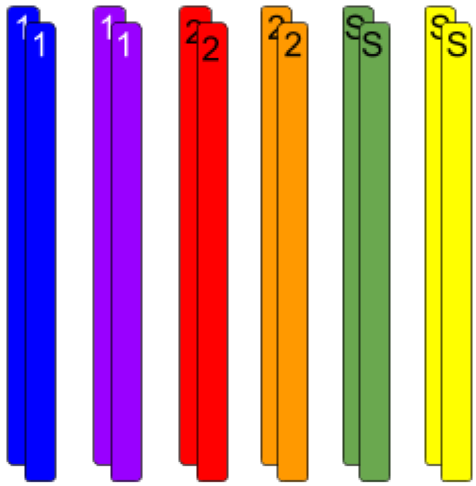
This bird has two pairs of **autosomes** (1 and 2) and one pair of **sex chromosomes** (S: Z or W). Remember: birds use the Z/W sex chromosome system.

What is the sex of your bird, based on its sex chromosomes (1 pt)? ____________________

2. Based on the alleles on your chromosomes, what is the full genotype of your bird(1 pt)?

Write as *IIRhRhFFGGHH*:____

3. Now your **germ cell** is going to undergo **meiosis.** The <u>first</u> step in **meiosis** is **synthesis**. Use your second set of "chromosomes" to "synthesize" new chromosomes:



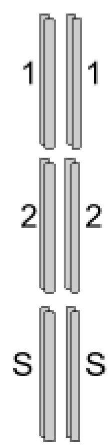
Is this cell **diploid** (yes/no) (1 pt)?_______________________

4. DNA polymerase has just synthesized (1 pt) (circle one):

Homologs   Sister Chromatids

These new chromosomes will have <u>virtually identical</u> sequences as the original chromosomes. **DNA polymerase** makes, on average, fewer than one nucleotide error per cell division! Notice that **alleles** on one **sister chromatid** are identical to **alleles** on the other, but **alleles** on **homologs** may be different.

5. The <u>second</u> step of **meiosis** is **meiosis I**, separation of (1 pt)_________________________.
Line them up along the midlines of your "cell" (desk). Write in the alleles below.

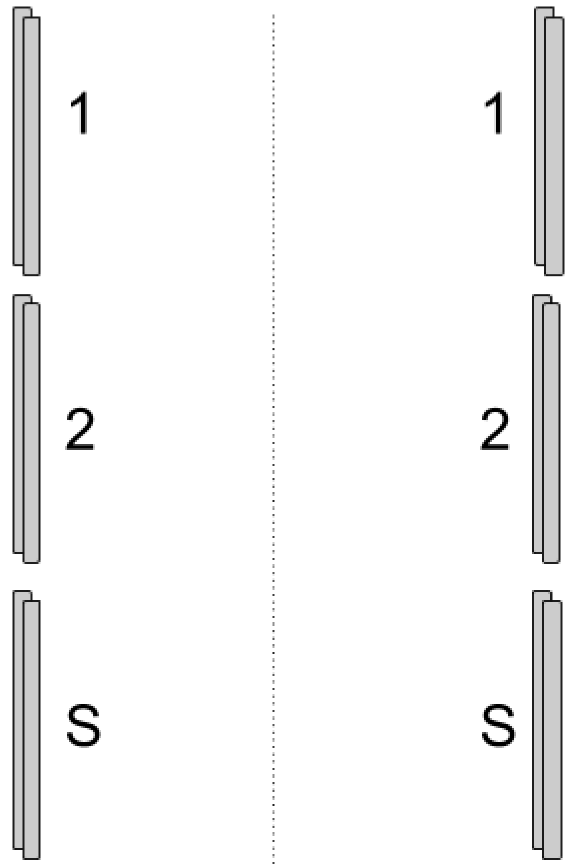


6. Separate your chromosomes and have your cell undergo **cytokinesis**. Now you have TWO cells.

Are these cells **diploid** (yes/no) (1 pt)?________________________

Write in the alleles below!

I Allele: ________________ I Allele: ___________________



Rh/F/G Alleles: __________________ Rh/F/G Alleles: ___________________

H Allele: _________________ H Allele: ___________________

This illustrates both of Mendel's laws.

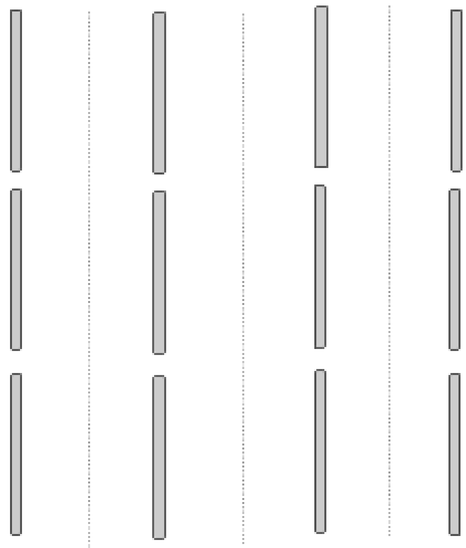
The **Law of Segregation** states: *"The two alleles of a gene segregate from each other during gamete production (meiosis)."* Notice how the same gene on **homologs** are now in different cells, even if they are different **alleles**? They have ***segregated*** from each other and can *never* end up in the same **gamete**.

Mendel's **Law of Independent Assortment** states: "*Alleles for two or more genes are independently assorted during gamete production (meiosis).*" See how different genes on **different chromosomes** (for example, chromosomes 1 and 2) can end up in the same cell, OR in different cells, depending on how you line up your chromosomes? They have ***independently assorted*** from each other. They may or may not be inherited together.

7. The last step of **meiosis** is **meiosis II**, separation of (1 pt)________________________.

Remember that you begin with TWO cells.

8. Separate your chromosomes according to **meiosis II**. Your cells undergo **cytokinesis**. You now have four **gamete** cells.

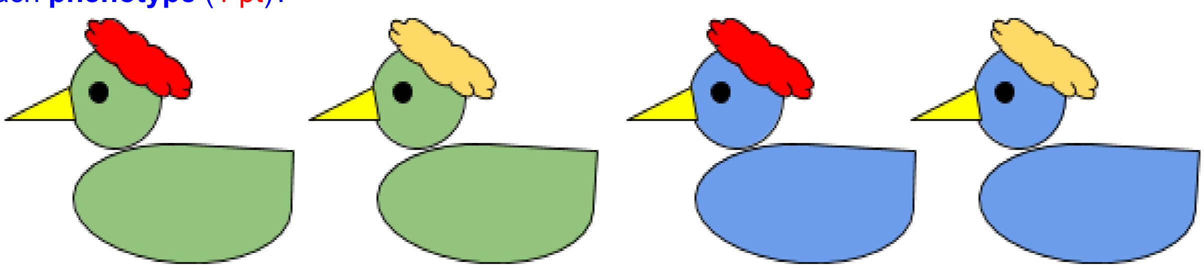


Are these cells **diploid** (yes/no) (1 pt)?______________________

9. Notice the F and G **loci** on chromosome 2 (red and orange). These alleles are ***linked*** because they are on the same chromosome; they are always inherited together. This is why Mendel's law of **Independent Assortment** only holds for genes on different chromosomes!

Can you ever end up with a **gamete** with the **haploid** genotype Fg (yes/no) (1 pt)?___________

10. The F/f **locus** controls plumage color and F (green) is **dominant** to f (blue). The G/g **locus** controls crest color and G (red) is dominant to g orange What are the possible **genotypes** for each **phenotype** (1 pt)?



(4)__________________ (2)________________ (2)______________ (1)______________

11. Now, you and your partner should each pick ONE of your **gametes**. It doesn't matter which one. It's ok to both pick gametes with orange chromosomes, for example.

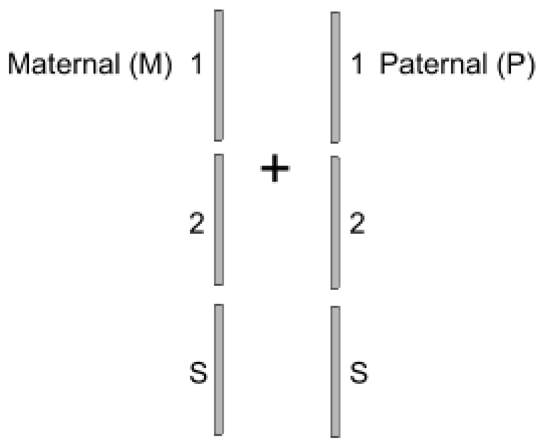
Which one of you is the "mother" and which is the "father"?

Together, fuse your **gametes** through **fertilization** into <u>one cell</u>. Write in the alleles below:

I Allele: ____________________

Rh/F/G Alleles: ____________________

H Allele: ____________________



I Allele: ____________________

Rh/F/G Alleles: ____________________

H Allele: ____________________

Is this cell **diploid** (yes/no) (1 pt)?________________________

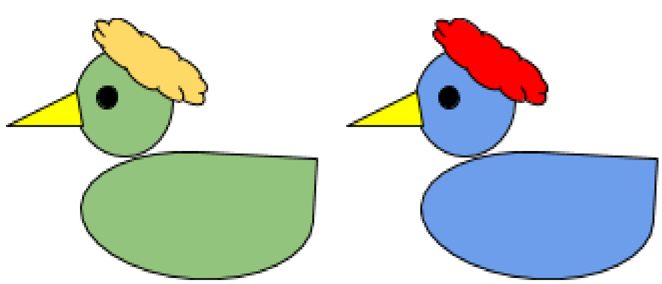
12. This cell represents a newly formed bird **embryo.**
What sex chromosomes does your bird embryo have? ________________

What is the sex of your bird embryo, based on its sex chromosomes (1 pt)? _____________

13. What is the <u>full genotype</u> of your bird embryo (1 pt)?

Write as *IIRhRhFFGGHH*: ____

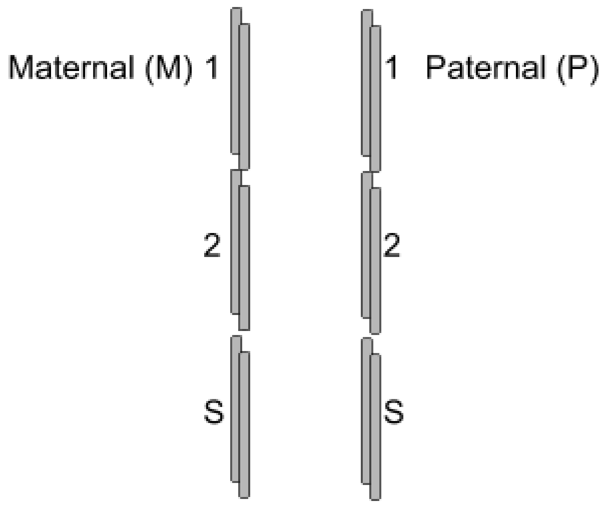
14. If you and your partner had chosen <u>any</u> of your gametes and combined them, what is the likelihood that you would have created a bird with one of the **phenotypes** below (1 pt)?



Answer in one sentence:

15. Your single celled embryo will now undergo MANY rounds of **mitosis** to make an multicellular bird. Let's do just ONE round of **mitosis**.

Just like **meiosis**, The first stage of **mitosis** is **synthesis**. Use your extra set of "chromosomes" leftover from your earlier **meiosis** to "synthesize" new chromosomes:



Is this cell **diploid** (yes/no) (1 pt)?________________________

16. DNA polymerase has just synthesized (1 pt) (circle one):

Homologs Sister Chromatids

17. The second stage of **mitosis** is separation of (1 pt)_________________________________.

I Allele: ___________________________

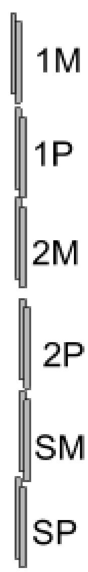
I Allele: ___________________________

Rh/F/G Alleles: _____________________

Rh/F/G Alleles: _____________________

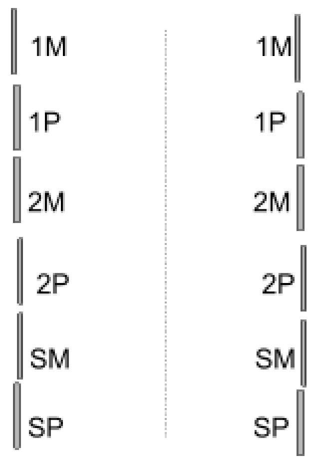
H Allele: ___________________________

H Allele: ___________________________



18. Line your chromosomes up as shown above. **How is this different than how chromosomes line up during meiosis I?** Write 1-2 sentences (1 pt).

19. Separate the chromosomes into two **daughter cells**:

Alleles: ____________________		Alleles: ____________________
Alleles: ____________________		Alleles: ____________________
Alleles: ____________________		Alleles: ____________________
Alleles: ____________________		Alleles: ____________________
Alleles: ____________________		Alleles: ____________________
Alleles: ____________________		Alleles: ____________________

Are these two cells **diploid** (yes/no) (1 pt)?______________________

20. Are these cells <u>genetically identical</u> to the **mother cell** (yes/no) (1 pt)?________________

Notice how Mendel's laws don't apply to **mitosis**! Each **daughter cell** ends up with one copy of each maternal and paternal chromosome. <u>There is no segregation or independent assortment!</u>

21. Surprise! Our hypothetical birds have similar blood types to humans (not really, just today)!

Blood type is controlled by <u>two **loci**</u> on two different chromosomes: the A/B/O **locus** is located on <u>chromosome 1</u> (blue/purple), while the Rhesus **locus** (Rh+/Rh-) is located on <u>chromosome 2</u> (red/orange).

The A/B/O locus has 3 **alleles**. While the I^A and I^B alleles are **codominant** (both alleles are expressed equally), the i allele is **recessive** to both I^A and I^B. Genotype ii is blood type O.

The A/B/O locus <u>genotype</u> of your bird embryo is (1 pt): ______________________________

22. The Rhesus locus has 2 **alleles**: the Rh+ allele is **dominant** to the Rh- allele.

The Rhesus locus genotype of your bird embryo is (1 pt): ______________________________

23. The *full* blood type of your bird embryo is (1 pt): ___________________________________
(for example, AB+, O-, B+, etc.)

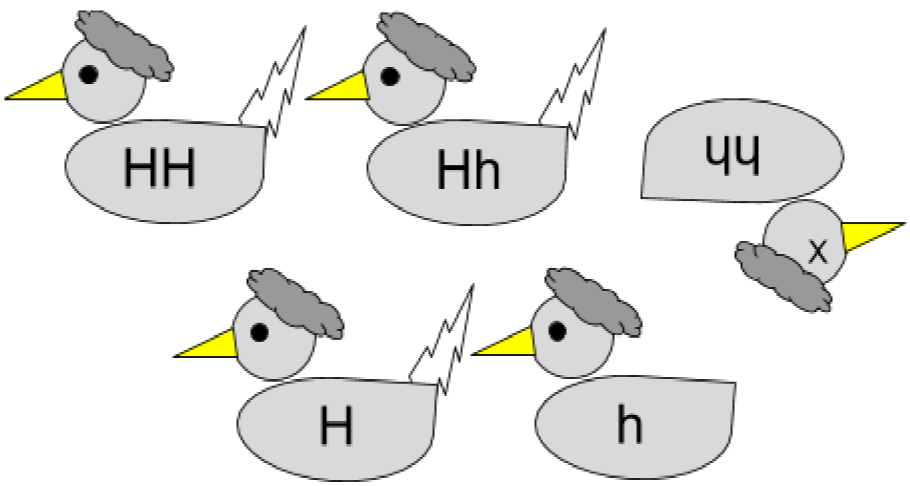
24. The H/h **locus** controls tail shape. The H **allele**, which confers a fancy tail, is **dominant** to the **recessive** h allele, which results in no tail at all.

The H locus is Z-linked, meaning that it is physically located on the Z **sex chromosome**.

There is no H locus on the W **sex chromosome** (Z and W are not **homologs**!).

ZZ males have two H/h loci (on Z homologs), while ZW females have only one H/h locus.

Females can survive without tails, but males cannot!



What is the sex of all ducks affected by “taillessness” disease (being alive but having no tail) (1 pt)?

____

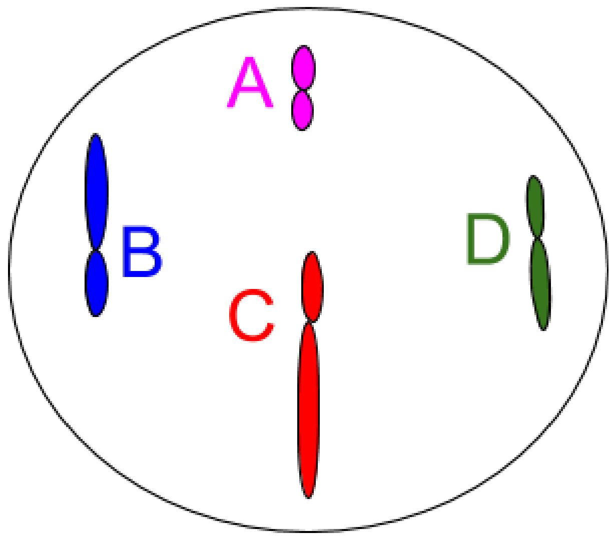
25. What is the sex of the animal that is a **carrier** for the **sex-linked** duck disease of “taillessness” (1 pt)?

____

The remainder of this homework should be completed out of class.

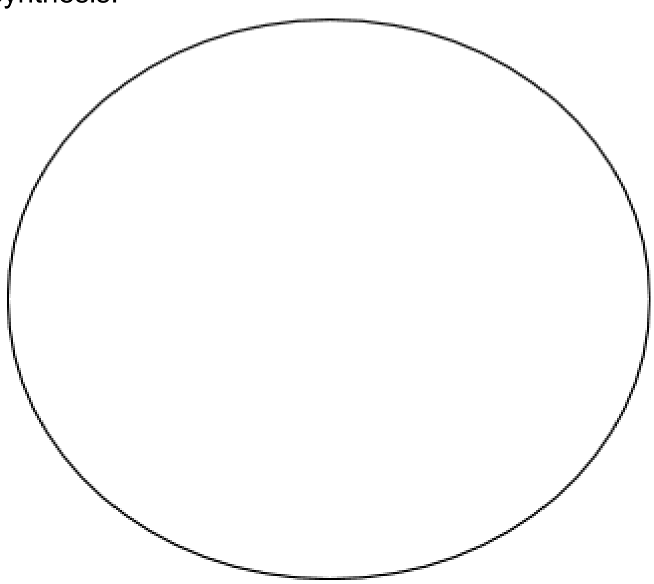
26. Bees are super cool! We discussed how queen larvae are fed royal jelly, while workers female larvae are fed "bee bread." You may remember from my presentation that plant "microRNAs" in pollen end up in bee bread and are important for keeping workers infertile!

The **sex determination** system in bees is way different than in many other organisms: females are **diploid** while males are **haploid**. Males develop from unfertilized eggs**(!).** Bees have 16 chromosomes, but to simplify let's say they have 4:

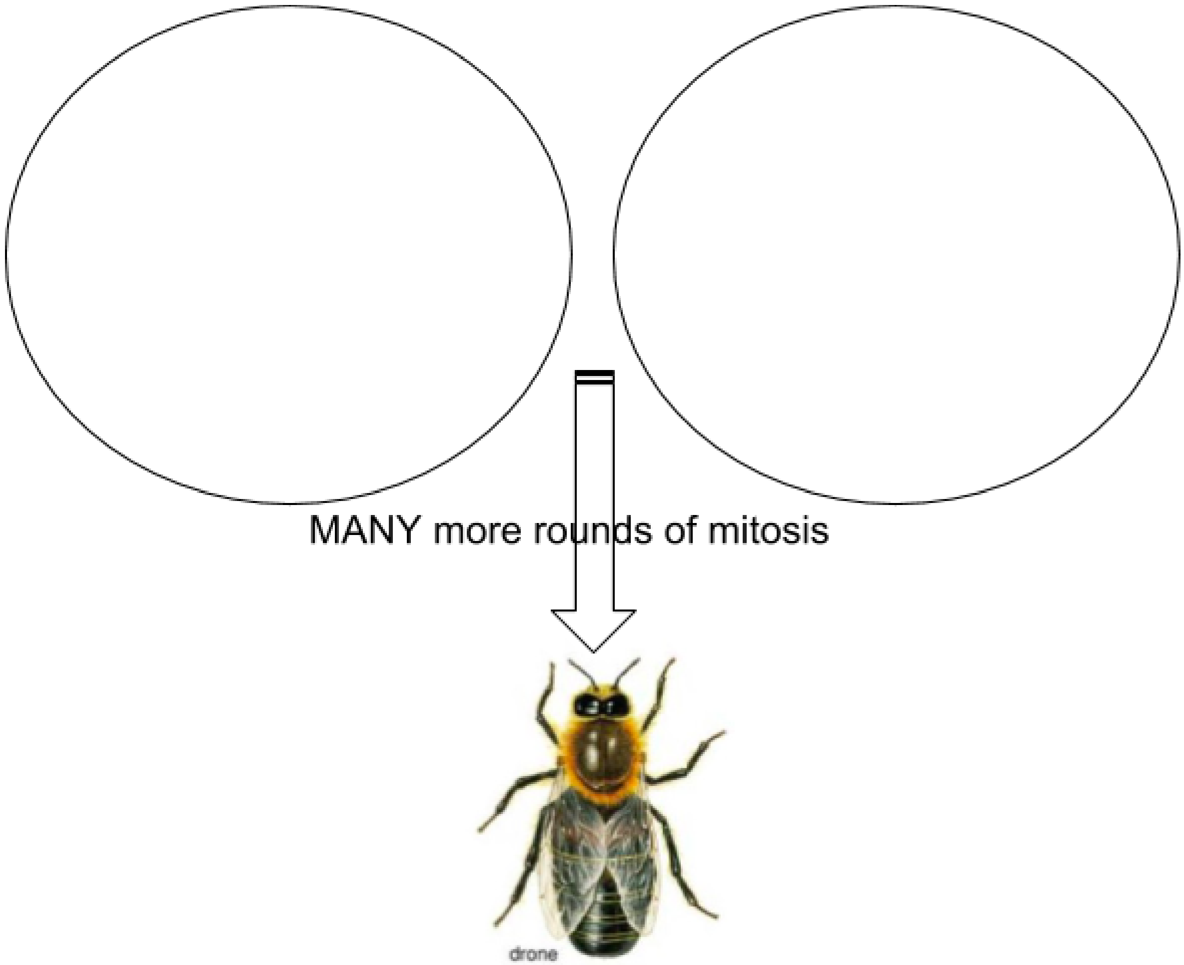


The above cell represents a **haploid egg** (**gamete** cell) laid by a queen bee. Even when unfertilized, it can undergo ***mitosis*** to form a **haploid** embryo that develops into a male drone bee**.** Diagram the two stages of **mitosis** the above **mother cell** will undergo. You may use the chromosome names (A-D) rather than colors.

First step (1 pt): DNA synthesis:



27. Second step (1 pt): Separation of **sister chromatids:**



28. Mitosis of a **haploid** egg creates a drone male bee. Are the above cells **haploid** or **diploid** (1 pt)?

29. In humans, the **wild-type** allele responsible for the ability to distinguish red from green (a form of colorblindness) is located on the **human X chromosome**. A **mutation** in this gene can result in color blindness. Is this likely a **gain-of-function** or **loss-of-function** allele (1 pt)?

30. The **wild-type** allele (B) that confers the ability to distinguish green from red is **dominant** to the allele with the mutation that results in red/green colorblindness (b). A woman has two X chromosomes. One carries the B allele, while the other carries the b allele. Is she red/green colorblind (1 pt) (yes/no)?

31. What are the **haploid** genotype(s) of the **gamete(s)** this woman will make (1 pt)?

32. This woman has a <u>male</u> child. What is the probability (in %) that her son will have red/green colorblindness (2 pts)?

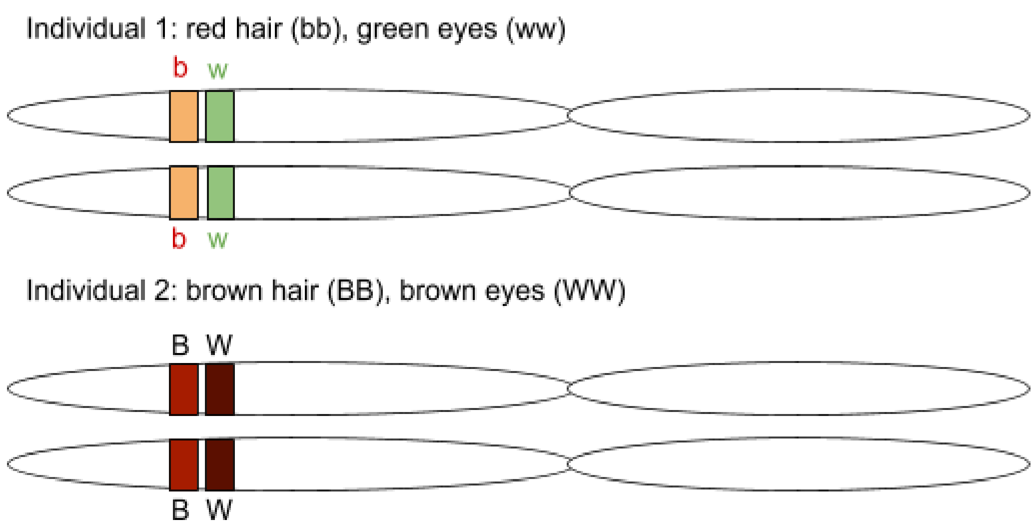
33. This woman has a <u>female</u> child. What is the probability (in %) that her daughter will be a **carrier** for the b allele (2 pts)?

34. In class we learned about Duchenne Muscular Dystrophy, which is caused by a **loss-of-function mutation** in the dystrophin gene. Dystrophin is located on the X-chromosome and Duchenne muscular dystrophy almost always affects males. Is this mutation **dominant** or **recessive** and how do you know (2 pts)?

35. A small, but significant, genetic contribution to male-pattern baldness is a gene on the **X-chromosome**, which men inherit solely from their mothers. In reality there are many other factors, but here let's say this gene is solely responsible for baldness in men. So to determine a man's likelihood of baldness, one should look at his <u>maternal grandfather's</u> scalp. If a man's maternal grandfather is bald, what is the probability that his grandson will inherit his sole X-chromosome and also be bald? How did you calculate this probability (2 pts)?

36. Autosomes and **X-chromosomes** have <u>many</u> more genes than the **Y-chromosome**. There are virtually no confirmed diseases that result from mutations in genes on the Y-chromosome! Hypothetically, a man has a mutation in a gene on his Y-chromosome and it leads to "unibrow syndrome." What is the probability that his son will also have "unibrow syndrome"? How do you know (2 pts)?

37. Think about it: there are very few people with red hair and brown eyes! While both of these traits in humans are affected by multiple genes, they are <u>found on the same chromosome</u>. Alleles for red hair are mostly **recessive** to alleles for brown hair, while alleles for brown eyes are mostly **dominant** to alleles for green eyes. Below, I have simplified each trait into a single **locus** character:



<u>Why</u> is it impossible to find a person with the **genotype** <u>bbWW</u> OR <u>bbWw</u> (red hair, brown eyes) (2 pts)?

38. Even some plants have sex chromosomes! While most plants (like Mendel's peas) are **hermaphroditic** (flowers have both male and female sex organs), some plants are "dioecious:" there are male individuals (their flowers have only male organs) and female individuals (their flowers have only female organs). Some plants are even "trioecious"-- there are THREE sexes!

An example of a trioecious species is papaya: females have two X chromosomes, males have an X and a Y, and hermaphrodites have an X and a Y_h.

Fill out the Punnett square below for the **selfing** of a hermaphrodite papaya (4 pts):

39. Sex chromosome combinations YY, Y Y_h, and Y_h Y_h, are lethal. What sex offspring do hermaphrodite papaya have and in what percentages (3 pts)?

Extra Credit!

In humans *biological* sex is determined by the presence or absence of a Y chromosome. This is different in different species, and it is not always so black and white in humans either! Please read the article [“From the finish line to the gender line” by NPR]. Sex is a pretty gray area…

Please give at least two reasons Semenya (and other **intersex** individuals) should be allowed to compete as a woman (1 pt):

Please give at least two reasons Semenya (and other **intersex** individuals) should NOT be allowed to compete as a woman (1 pt):