Relating Mendel's Laws to Meiosis

Name: ____Solution_____

Materials: two of each gene. There are pink genes, red, yellow and blue genes. Each has an allele marked on it. An allele is a trait – dominant is capital and recessive is a small letter.

1. How many possible ways can two genes combine to make different gametes (drawing it out should help you visualize the combinations)?

   Let's say you have a chromosome pair we'll label as Aa and another pair that's Bb. This could make: Ab, AB, ab, aB That's four possible combinations.

2. How many possible ways can three genes combine to make different gametes (draw it out)?

   Now we can add chromosome C to the above. That means we have either a C or c to the four above giving eight total. Abc, ABc, abc, aBc then AbC, ABC, abC, aBC

3. How many possible ways can 22 genes combine to make different gametes?

   4. *Each time we add a gene it doubles what we had. So 2 genes were 2 x 2 = 2^2 = 4, 3 genes is 4 x 2 = 2^3 = 8 and so on until we get to 22 genes. That's 2^{22} = 4,194,304 unique combinations. That's just possible sperm or eggs. Combine those and you get a possible 17 trillion unique children from one couple. That's without the variation that comes in when the genes crossover (shown as the third circle in the above diagram).*

Next we'll create possible children based on the parents genetic make-up.

4. Create a father and a mother who are both heterozygous for each gene. Heterozygous means they have one of each (dominant and recessive copy of a chromosome pair.) *(chromosomes were drawn randomly so your answers will probably not look exactly the same.)*

	Child 1	Child 2	Child 3	Child 4
Chromosome Pink				
Chromosome Red				
Chromosome Yellow				
Chromosome Blue				

5. Are all the possible combinations of children shown above? Hint: Look at questions 6, 7 and 8 on the Mitosis vs. Meioses activity.

   No. There are 2^4 = 16 possible combinations with four genes for each gamete and then they combine giving 16 x 16 = 256 possible combinations for the children. The chart above only has 16 possibilities.

6. How would the children be different if we started with parents who were both homozygous recessive for all 4 genes? Homozygous means they have both copies of a chromosome the same.

	Child 1	Child 2	Child 3	Child 4
Chromosome Pink				
Chromosome Red				

	Child 1	Child 2	Child 3	Child 4
Chromosome Yellow				
Chromosome Blue				

7. How would the children be different if we started with one parent who is homozygous dominant and one that is homozygous recessive for all 4 genes?

	Child 1	Child 2	Child 3	Child 4
Chromosome Pink				
Chromosome Red				
Chromosome Yellow				
Chromosome Blue				

Relating Inheritance to probability calculations

To calculate the chance that some particular genotype will result from a certain cross, one has to understand probability – the chance that something will happen. The chance that you'll roll a 4 on a 6 sided die is 1/6.

Independent events are multiplied together: for example the chance that you will roll two 4's in a row on a die is 1/6 x 1/6 = 1/36

Dependent events are added together: for example, the chance that you will roll a 3 or a 4 on a six sided die is 1/6 + 1/6 = 1/3.

Use only 2 genes for questions 8-10. Pink and Yellow. Start with each parent being heterozygous for each. Gg Ff.

8. Is the chance that the child will inherit the "g" allele on chromosome pink independent or dependent on whether the child will inherit the "F" allele on chromosome yellow?

Independent. What happens with the pink chromosome has no effect on what happens with the yellow chromosome.

9. a. What is the chance that a gamete (sperm or egg) would contain the "g" allele?

50%. An egg (or sperm) will get either the "G" or the "g".

b. What is the chance that a gamete would contain the "F" allele?

50%. An egg (or sperm) will get either the "F" or the "f".

c. What is the chance that a gamete would contain "g" and "F" (be genotype Fg)?

50% x 50% = 25%

10. Try using a Punnett Square to figure these probabilities.

a. Draw a Punnett Square to identify all the possible gametes a parent can make.
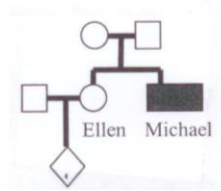
Mom's gametes:

	G	g
F	FG	Fg
f	fG	fg

Dad's gametes:

	G	g
F	FG	Fg
f	fG	fg

b. Make another square using the possible gametes from a. and fill in all the possible children.

Mom across the top and Dad down the side.

	FG	Fg	fG	fg
FG	FFGG	FFGg	FfGG	FfGg
Fg	FFGg	FFgg	FfGg	Ffgg
fG	FfGG	FfGg	ffGG	ffGg
fg	FfGg	Ffgg	ffGg	ffgg

Problems:

Ellen Michael

11. Ellen does not have blue eyes, but her brother Michael has this recessive trait (see pedigree above). Are either, both, or neither of the parents of Ellen and Michael heterozygous (carries) of blue eyes?

Michael can only have this recessive trait if both of his chromosomes are for blue eyes. This means both parents had to be carriers.

12. Make a Punnett Square to help figure out what the probability is that Ellen is a carrier of blue eyes.

	B	b
B	BB	Bb
b	Bb	bb

Ellen can only be 1 of 3 children since she has brown eyes. The 4th has blue eyes. 2 out of these 3 children from Ellen's parents will be a carrier who does not have blue eyes. That means there's a 67% chance Ellen is a carrier.

13. Ellen wonders if her unborn child will have blue eyes. Ellen's husband is not a carrier. What is the probability that the child will have blue eyes?

If Ellen's husband is not a carrier, her child cannot have blue eyes. Both parents must either be carriers or have blue eyes to have a blue eyed child.

14. If Ellen is a carrier, what is the probability that the child will also be a carrier? Make a Punnett Square assuming that Ellen is a carrier while her husband is not.

	B	b
B	BB	Bb
B	BB	Bb

There is a 50% chance that Ellen's child will be a carrier.

15. If Ellen is not a carrier, what is the chance that the child will be a carrier?

There is no chance if Ellen is not since we know that her husband is not.

16. What is the overall chance that Ellen's child will be a carrier (taking into account the possibility that Ellen might not be a carrier)?

2/3 chance or 67% that she is a carrier. If she is a carrier then ½ or 50% chance that the child will also be a carrier. So 2/3 x ½ = 1/3 or 33%.

17. Straight hair is a recessive trait. Ellen and her husband both have straight hair. What are the chances that their child will have straight hair?

If straight hair is recessive then both of each Ellen and her husband's genes are for straight hair.

Child must have straight hair.