Name KEY Period ______

Mendelian Genetics Problems

SHOW ALL WORK AND PUNNETT SQUARES!!!

Set #1: Oompah Loompa Genetics

1. Oompahs generally have blue (B) faces which is caused by a dominant gene. The recessive condition results in an orange (b) face. Develop a "key" to show the genotypes and phenotypes possible for Oompa Loompas.

BLUE = BB or Bb

ORANGE = bb

2. Two heterozygous (Bb) OOmpahs are crossed. What proportion of the offspring will have orange faces?

Bb × Bb

	B	b
B	BB	Bb
b	Bb	bb

Genotypes – 1BB : 2Bb : 1bb

Phenotypes – 3 BLUE : 1 ORANGE

3. Otis Oompah has an orange (bb) face and is married to Ona Oompah who has a blue (BB or Bb) face. They have 60 children, 31 of them have orange faces. What are the genotypes of the parents?

Otis = bb Ona = ~~BB~~ or Bb

1) (crossed out)

	B	B
b	Bb	Bb
b	Bb	Bb

or

2)

	B	b
b	Bb	bb
b	Bb	bb

Ona must be heterozygous (Bb) in order to have orange faced children.

4. Odie Oompah has a blue face. In fact, everyone in Odie's family has a blue face, and the family boasts that it is a "pure" line. Much to his family's horror, he married Ondi Oompah who "gasp" has an orange face. What are the gentoypes of their children. Is Odie's line still "pure"?

Odie = Pure BLUE = BB Ondie = Orange = bb

BB × bb

	B	B
b	Bb	Bb
b	Bb	Bb

All offspring will be heterozygous (Bb) blue.

5. Ondi (bb) Oompah (from#4) divorces Odie and marries Otto. Otto has a blue face, but his father had an orange face. What is the probability that Ona and Otto's children will have orange faces?

Ondi = bb Otto = ~~BB~~ or Bb

Otto's dad = bb =>

	B	b
b	Bb	bb
b	Bb	bb

Otto has to be heterozygous (Bb) because his father could only pass on a recessive allele (b) because he was homozygous recessive (bb). This means Ondi & Otto will have a 50% chance for orange faced kids.

Set #2: Misc. problems

1. Mating a red-eyed fly and a pink-eyed fly yields only red-eyed offspring. (Red eyes is dominant over pink-eyes)

Red = RR or Rr
Pink = rr

RR x rr

a. What is the genotype of these offspring?

	R	R
r	Rr	Rr
r	Rr	Rr

⇒ all offspring are Rr.

b. If one of these red-eyed offspring is mated to its pink-eyed parent, what will their offspring be like? (Give both genotypes and phenotypes)

Rr x rr

	R	r
r	Rr	rr
r	Rr	rr

genotypes = 2Rr : 2rr
phenotypes – 2red : 2pink

2. In sheep, white (W) is due to a dominant gene and black (w) is due to its recessive allele. A white ewe mated to a white ram produces a black lamb. What are the parent genotypes?

WW or Ww

a. If they produce another offspring, could it be white?

Yes! The parents must have been heterozygous (Ww) in order to be white & have a black (ww) lamb. Therefore they have a 25% chance of having another black lamb.

	W	w
W	WW	Ww
w	Ww	ww

b. If so, what are the chances of it being white?

75% →

3 out of 4.

c. List the genotype of all the sheep in this problem.

1 WW : 2 Ww : 1 ww

Name: Key – Brown Bio Period: ________ Date: 2016

Non-Mendelian Inheritance

Incomplete Dominance: Type of inheritance patter where the dominant allele does NOT fully over power the recessive allele in the heterozygous genotype. The heterozygous individual's phenotype is a **BLENDING** of the two traits. RR "stronger" than Rr

Example: Red flowers(R) are incompletely dominant over white flowers (r).

RR phenotype: Red Rr phenotype= pink rr phenotype= White

Practice:

1. Coat color in mice is incompletely dominant. Yellow (YY) and white-colored (yy) mice are homozygous, while cream-colored mice are heterozygous. If two cream-colored mice mate, **what phenotypic ratio can we expect of their offspring**? Yy

Yy x Yy
cream X cream

	Y	y
Y	YY	Yy
y	yy	yy

genotypic ratio
1 YY : 1 Yy : 1 yy
phenotypic ratio
1 yellow : 2 cream : 1 white

2. In radishes, red and white are pure-breeding colors, while hybrids are purple. If a red radish is crossed with a white radish, **what will be the phenotype of the F_2 generation (assuming the F_1 generation self-pollinates)?**

RR red Rr purple white rr

P RR x rr → Rr F1

	R	R
r	Rr	Rr
r	Rr	Rr

F1 X F1 → F2

	R	r
R	RR	Rr
r	Rr	rr

F2 genotypic ratios
1 RR : 2 Rr : 1 rr

1 red : 2 purple : 1 white

Name: ______________________ Period: ________ Date: ________

***Co-Dominance*:** Type of inheritance pattern where there are two dominant alleles and **no recessive alleles** (therefore, no lower case letters are used). When the both dominant alleles are inherited, **BOTH** traits are expressed in the phenotype separately from each other. **This is the only time you may use different letters for alleles.**

Example: Black fur (B) and white fur (W) are co-dominant alleles in mice.

BB phenotype= BB WW phenotype= WW BW phenotype= BW

Practice: or H^BH^B or H^WH^W or H^BH^W

3. Roan cattle are the heterozygous hybrids of a cross between a white bull (W) and a red cow (R). If a roan bull were crossed with a red cow, **what would be the possible phenotypes of their offspring?**

WW = white RR = red WR = red and white (roan)

P WW x WR → F1

or C^WC^W x C^WC^R

	W	W
W	WW	WW
R	WR	WR

genotypic ratio 2WW : 2WR

2 white : 2 roan phenotypic ratio

Co-dominance/Multiple Alleles

Human blood types are determined by genes that follow the CODOMINANCE pattern of inheritance. There are two dominant alleles (I^A and I^B) and one recessive allele (i). or A and B or ø

Blood Type (Phenotype)	Genotype	Can donate blood to:	Can receive blood from:
O	ii	any blood type A, B, AB, O	only O
AB	I^AI^B or AB	only AB	anyone A, B, AB, O
A	I^AI^A or I^Ai (or AA, Aø)	only A or AB	A or O
B	I^BI^B, I^Bi or BB or Bø	B or AB	B or O

Use I to show A + B are both dominant alleles of the same gene & i to show the recessive of the same gene

Name: ______________________ Period: ________ Date: ________

1. Write the genotype for each person based on the description:

   a. Homozygous for the "B" allele $I^B I^B$ or BB
   b. Heterozygous for the "A" allele $I^A i$ or Aϕ
   c. Type O ϕϕ or ii
   d. Type "A" and had a type "O" parent $I^A i$ or Aϕ
   e. Type "AB" $I^A I^B$ or AB
   f. Blood can be donated to anybody ii or ϕϕ
   g. Can only get blood from a type "O" donor ii

2. Pretend that Brad Pitt is homozygous for the type B allele ($I^B I^B$), and Angelina Jolie is type "O." (ii) What are all the possible blood types of their baby?

P: $I^B i \times ii$ = $I^B i$ or ii possible F1

	I^B	i
i	$I^B i$	ii
i	$I^B i$	ii

genotypic ratios $2 I^B i : 2 ii$

phenotypic ratio 2 type B : 2 type O

3. Draw a Punnett square showing all the possible blood types for the offspring produced by a type "O" mother and an a Type "AB" father

P $ii \times I^A I^B$

	I^B	I^A
i	$I^B i$	$I^A i$
i	$I^B i$	$I^A i$

$2 I^B i : 2 I^A i$ genotypic ratio

phenotypic ratios

2 B : 2 A

Name: ______________________ Period: ________ Date: __________

4. 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: ii

   b. Father's genotype: I^AI^B

   c. Baby's genotype: I^BI^B or I^Bi

   d. Punnett square showing all possible genotypes for children produced by this couple

	i	i
I^A	I^Ai	I^Ai
I^B	I^Bi	I^Bi

   e. Was the baby switched?

   probably not — 50/ chance of

5. Based on the information in this table, which men **could not** be the father of the baby? Justify your answer with a Punnett square.

Name	Blood Type
Mother	Type A
Baby	Type B
Father 1	Type O
Father 2	Type AB
Father 3	Type A
Father 4	Type B

Mother I^Ai or I^AI

baby B I^Bi only

Father can not be type A or type O

A dad

	I^A	i
I^A	I^AI^A	I^Ai
i	I^Ai	ii

no B babies possible w/ A father

O dad

	I^A	i
i	I^Ai	ii
i	I^Ai	ii

no B Babies possible

Incomplete and Co-Dominance Genetic Problems

Please solve your problems and show your work on a separate sheet of paper.

1. A person that is heterogeneous for type A blood and a person with type AB blood marry and plan to have many children. What will the possible genotypes, phenotypes and their ratios be for the children?

2. Horse that produce roan coats have co-dominant red and white alleles for hair color. What are the possible genotypes and phenotypes of the offspring between two heterozygous roan coat horses?

3. A new species of a large carnivorous cat has been found called the Gats. In Gats black and white spots are co-dominant. If a heterozygous spotted Gat is crossed with a white spotted Gat, what would be the phenotype(s) and genotype(s)of the offspring?

4. In dogs there are black Labrador retrievers and tan colored Labs. If a black and tan colored Labs are crossed all their offspring are a brown/chocolate color.

   A. Is this incomplete dominance or co-dominance?

   ____

   B. If a black Lab was crossed with a tan colored Lab, what would be the genotype, phenotypes, and the ratios for their offspring.

5. In a pepper plant the gene for green peppers was incompletely dominant over the gene for yellow peppers. What would the result be of crossing two heterozygous olive colored pepper plants? List possible genotype and phenotype. What percentage would be yellow colored?

① $I^A i \times I^A I^B$ =

	I^A	i
I^A	$I^A I^A$	$I^A i$
I^B	$I^A I^B$	$I^B i$

ph. ratio: 1 AB : 2A : 1B

Non-Mendelian Inheritance Notes: Part 2

many genes

A. Polygenic Inheritance

a. Most of your traits are controlled by the interaction of many genes.

b. Multiple genes working together produce a continuous distribution in a "normal curve" curve of degrees. (Bell-shaped curve)

c. Examples of polygenetic traits

i. Body Type

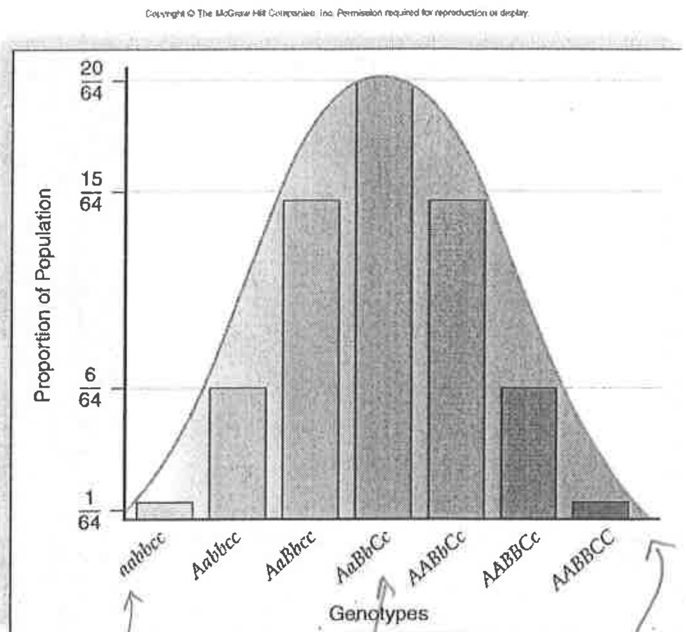
ii. Height

iii. Skin Color

iv. Hair color

v. Eye color

vi. Intelligence



weakest phenotype   average   strongest phenotype

d. The environment heavily influences polygenic inheritance.

B. Autosomal Dominant Disorders

a. Autosomal dominant is one of several ways that a trait or disorder can be passed down through families.

b. **Caused by the presence of a dominant allele.** on an autosome

c. If a disease is autosomal dominant, it means you only need to get the abnormal allele from one parent in order for you to inherit the disease. One of the parents may often have the disease.

d. Examples

i. Huntington's disease

1. HH or Hh = diseased
2. hh = healthy

HH usually dies in childhood

ii. Neurofibromatosis

1. NN or Nn = diseased
2. nn = healthy

C. Autosomal Recessive Disorders autosomal

a. Caused by inheriting 2 recessive alleles.

b. An autosomal recessive disorder means **two copies** of an abnormal allele must be present in order for the disease or trait to develop **(aa).**

c. A person who is heterozygous (Aa) is considered a "Carrier" of the gene. healthy!

d. Examples

i. albinism

1. AA= unaffected
2. Aa = unaffected carrier
3. aa = affected — albino

ii. Tay sack's

1. TT= unaffected — healthy
2. Tt = unaffected (but healthy!) carrier
3. tt = affected diseased

iii. Cystic Fibrosis

1. CC= Unaffected
2. Cc = Unaffected carrier
3. cc = diseased (affected)

D. Sex-Linked Inheritance

a. Follows Mendel's principle of dominance however **the genes that are located on the** X or Y sex chromosomes (usually on the larger X)

b. Sex chromosomes (X and Y)

c. female = XX Male = XY

i. X^H = dominant allele

ii. X^h = recessive allele

d. Because the allele is located on the X chromosome, Recessive sex-linked genetic disorders are more common in males!

e. Examples

i. Color blindness

ii. hemophilia

iii. SCIDS

iv. ______________

Hemophilia (X^h) is a sex-linked recessive disorder.

FEMALE GENOTYPES	PHENOTYPES
$X^H X^H$	healthy ♀
$X^H X^h$	healthy Carrier ♀
$X^h X^h$	hemophiliac ♀

MALE GENOTYPES	PHENOTYPES
$X^H Y$	healthy ♂
$X^h Y$	hemophiliac ♂

Sample Problem #1:

Hemophilia is a sex-linked recessive condition. Beyonce is a carrier ($X^H X^h$) of hemophilia and Jay-Z is normal. What are the chances of them having a child with hemophilia?

$X^H Y$

Parent Genotypes: $X^H X^h$ x $X^H Y$

	X^H	Y
X^H	$X^H X^H$	$X^H Y$
X^h	$X^H X^h$	$X^h Y$

1/4 of sons will be hemophiliac

no daughters will have hemophilia but half girls will carry the disorder

$X^C X^C \times X^{\not c} y$

Sample Problem #2:

Kim Kardashian is normal for colorblindness and Kanye West is color blind. What are the chances of them having a color blind child?

Parent Genotypes: $X^C X^C$ x $X^{\not c} y$

	$X^{\not c}$	y
X^C	$X^C X^{\not c}$	$X^C y$
X^C	$X^C X^{\not c}$	$X^C y$

no children will be color blind, but all females will be carriers

Sample Problem #3:

$X^B y$ $X^B X^b$

Will Smith is normal for male-pattern baldness, but Jada Pinkett Smith is a carrier. What are the chances of their daughter, Willow, being a carrier? Is it possible for their son, Jaden, to have inherited male pattern baldness?

Parent Genotypes: $X^B X^b$ x $X^B Y$

	X^B	X^b
X^B	$X^B X^B$	$X^B X^b$
Y	$X^B Y$	$X^b Y$

50% chance Willow is a carrier

50% chance Jaden has inherited m. P baldness

Level 1-2 Practice: Incomplete and Co-Dominance Genetic Problems

1. In dogs there are black Labrador retrievers and tan colored Labs. If a black and tan colored Labs are crossed all their offspring are a chocolate color. BLACK = BB TAN = bb CHOCOLATE = Bb
   A. Is this incomplete dominance or co-dominance? Explain.
   Incomplete dominance b/c the chocolate phenotype is a blend of BLACK & TAN.

   B. If a black Lab was crossed with a tan colored Lab, what would be the genotypic and phenotypic ratio of the offspring?

   BB x bb

	B	B
b	Bb	Bb
b	Bb	Bb

   All four will be (Bb) heterozygous for chocolate color.

2. In a pepper plant the gene for green (GG) peppers was incompletely dominant over the gene for yellow (gg) peppers. What would the result be of crossing two heterozygous olive (Gg) colored pepper plants? List the genotypic and phenotypic ratio of the offspring.

   GG = Green
   gg = yellow
   Gg = Olive

   Gg x Gg

	G	g
G	GG	Gg
g	Gg	gg

   1 GG : 2 Gg : 1 gg
   1 green : 2 olive : 1 yellow

3. In ~~dogs~~, there are black Brazilian short hair cats and white Brazilian short hair cats. If a black and a white colored cat are crossed all their offspring are white with black spots. BLACK = BB white = WW spots = BW
   A. Is this incomplete dominance or co-dominance? Explain.
   This is co-dominance because both traits are expressed as spots.

   B. If a spotted (BW) cat is crossed with a white (WW) cat, what would be genotypic and phenotypic ratios of the offspring?

   BW x WW

	B	W
W	BW	WW
W	BW	WW

   Genotypes – 2 BW : 2 WW
   phenotypes – 2 spots : 2 white

4. Horse that produce roan coats have co-dominant red (RR) and white (WW) alleles for hair color. What are the genotypic and phenotypic ratios of the offspring between two heterozygous roan coat horses?

Red = RR
white = WW
Roan = RW

RW × RW

	R	W
R	RR	RW
W	RW	WW

Genotypes: 1 RR : 2 RW : 1 WW
Phenotypes: 1 Red : 2 Roan : 1 white

5. A person that is heterozygous for type A blood ($I^A i$) and a person with type AB blood ($I^A I^B$) marry and plan to have many children.

$I^A i \times I^A I^B$

	I^A	i
I^A	$I^A I^A$	$I^A i$
I^B	$I^A I^B$	$I^B i$

Geno – 1 $I^A I^A$: 1 $I^A i$: 1 $I^A I^B$: 1 $I^B i$
Pheno – 2 Type A : 1 Type B : 1 Type AB

What are the chances of having a child with each blood type listed below?

Type A? 2/4 50%

Type B? 1/4 25%

Type AB? 1/4 25%

Type O? 0/4 0%

6. Kelly has type A blood and Zach has type B blood. They have a child who has type O blood. Make a Punnett Square to show how this is possible.

Type A = $I^A I^A$ or $I^A i$
Type B = $I^B I^B$ or $I^B i$

⟹

	I^A	i
I^B	$I^A I^B$	$I^B i$
i	$I^A i$	$i i$

Name KEY

Practice: Codominance and Incomplete Dominance

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. (CD)
Blue = BB   White = WW   Blue-Tip = BW

b) Flowers can be white, pink, or red. (IC)
Red = RR   Pink = Rr   White = rr

c) A Hoo can have curly hair, spiked hair, or a mix of both curly and spiked. (CD)
Curly = CC   Spiked = SS   Both = CS

d) A Sneech can be tall, medium, or short. (IC)
Tall = TT   Medium = Tt   Short = tt

e) A Bleexo can be spotted, black, or white. (CD)
Black = BB   White = WW   Spotted = BW

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

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   Co-Dominant

Circle   Stare   Both

CC   SS   CS

4. Show the cross between a star-eyed and a circle eyed.
What are the phenotypes of the offspring? All Both
What are the genotypes? All CS

SS × CC

	S	S
C	CS	CS
C	CS	CS

5. Show the cross between a circle-star eyed, and a circle eyed.
How many of the offspring are circle-eyed? 2/4
How many of the offspring are circle-star eyed? 2/4

CS × CC

	C	S
C	CC	CS
C	CC	CS

6. Show the cross between two circle-star eyed.

CS x CS

How many of the offspring are circle-eyed? 1/4

How many of the offspring are circle-star eyed? 2/4

How many are star eyed? 1/4

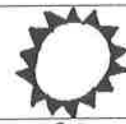
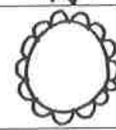
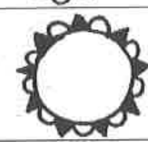
	C	S
C	CC	CS
S	CS	SS

Were the babies switched?

Two couples had babies on the same day in the same hospital. Denise and Earnest had a girl, Tonja. Danielle and Michael had twins, a boy, Michael, Jr., and a girl, Michelle. Danielle was convinced that there had been a mix-up and she had the wrong girl, since Michael Jr. and Tonja were both light-skinned, while Michelle was dark skinned. Danielle insisted on blood type tests for both families to check whether there had been a mix-up. In order to interpret the results of the blood type tests, you will need to understand the genetics of blood types.

Blood Types

The ABO blood type system is the major blood type classification system that determines which type of blood can safely be used for a transfusion. The four blood types in the ABO system are Type A, Type B, Type AB, and Type O. These blood types refer to different versions of carbohydrate molecules (complex sugars) which are present on the surface of red blood cells.

People with:	Have:	
Type A blood	Type A carbohydrate molecules on their red blood cells	
Type B blood	Type B carbohydrate molecules on their red blood cells	
Type AB blood	Type A and B carbohydrate molecules on their red blood cells	
Type O blood	Neither A nor B carbohydrate molecules on their red blood cells	

Genetics of Blood Types

These blood types result from the alleles of a gene that can code for two different versions of a protein enzyme or an inactive protein, as shown in the following table:

Allele	Codes for a protein that is
I^A	a version of the enzyme that puts Type A carbohydrate molecules on the surface of red blood cells
I^B	a version of the enzyme that puts Type B carbohydrate molecules on the surface of red blood cells
i	inactive; doesn't put either type of carbohydrate molecule on red blood cells

1. Each person has two copies of this gene, one inherited from his/her mother and the other inherited from his/her father. Complete the following table to relate genotypes to blood types.

Genotype	This person's cells make:	Blood Type
$I^A I^A$	the version of the enzyme that puts Type A carbohydrate molecules on the surface of red blood cells.	Type A
i i	the inactive protein.	Type O
$I^A i$	both the version of the enzyme that puts Type A carbohydrate molecules on the surface of red blood cells and the inactive protein.	Type A

2. In a person with the $I^A i$ genotype, which allele is dominant, I^A or i? Explain your reasoning.

Type I^A is dominant because a person heterozygous for A ($I^A i$) will still have "A" antigens.

3. For the genotypes listed below, which type(s) of enzyme would this person's cells make? What blood type would the person have?

Genotype	Will this person's cells make the version of the enzyme needed to attach this carbohydrate on the surface of his or her red blood cells?		Blood Type
$I^B I^B$	Type A ___yes X no;	Type B X yes ___ no	B
$I^B i$	Type A ___yes X no;	Type B X yes ___ no	B
$I^A I^B$	Type A X yes ___ no;	Type B X yes ___ no	AB

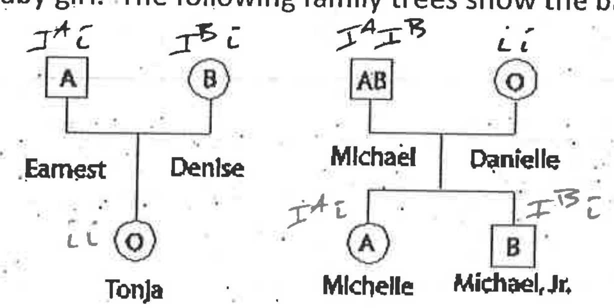
Codominance refers to inheritance in which two alleles of a gene each have a different observable effect on the phenotype of a heterozygous individual. Thus, in codominance, neither allele is recessive — both alleles are dominant.

4. Which of the genotypes results in a blood type that provides clear evidence of codominance? Explain your reasoning.

Type AB shows codominance because a person with type AB blood has the same antigens as both Type A and Type B antigens.

Were the babies switched?

Now you are ready to evaluate whether Earnest and Denise's baby girl was switched with Michael and Danielle's baby girl. The following family trees show the blood types for each person in both families.



5. What allele for the blood type gene will be present in each egg produced by Danielle? i

Michael can produce sperm with either the I^A allele or the I^B allele.

Draw the Punnett Square that shows the possible genotypes for Danielle and Michael's children. Write in the blood type for each genotype to show the possible blood types for Danielle and Michael's children.

	I^A	I^B
i	$I^A i$	$I^B i$
i	$I^A i$	$I^B i$

Is it possible for Danielle and Michael to have a child who has type O blood?

No. Michael can not pass on a recessive allele.

6. To check whether Earnest and Denise could have a baby with Type O blood, draw a Punnett square for a father who has blood Type A and $I^A i$ genotype and a mother who has blood Type B and $I^B i$ genotype. Write in the blood type for each child's genotype.

	I^A	i
I^B	$I^A I^B$	$I^B i$
i	$I^A i$	ii

1 $I^A I^B$ = AB
1 $I^A i$ = A
1 $I^B i$ = B
1 ii = O

1 A : 1 B : 1 AB : 1 O

7. Were Earnest and Denise the parents of Tonja or had the hospital made a mistake? Explain your reasoning.

Yes. Earnest & Denise are heterozygous. therefore Tonja got recessive alleles from both parents.

	I^A	i
I^B	$I^A I^B$	$I^B i$
i	$I^A i$	ii

Key

Lab, section 3
2/9/2015

Mystery: Baby Whose? Can this marriage be saved?

Mr. Woo is married to Ms. Hoo. Ms. Hoo recently gave birth to a baby. Mr. Woo's joy turned to fear when he noted that the baby looked nothing like him, especially since he has been hearing rumors of a long time affair between his wife and Mr. Boo. Is he imaging it...or does the baby look like Mr. Boo?

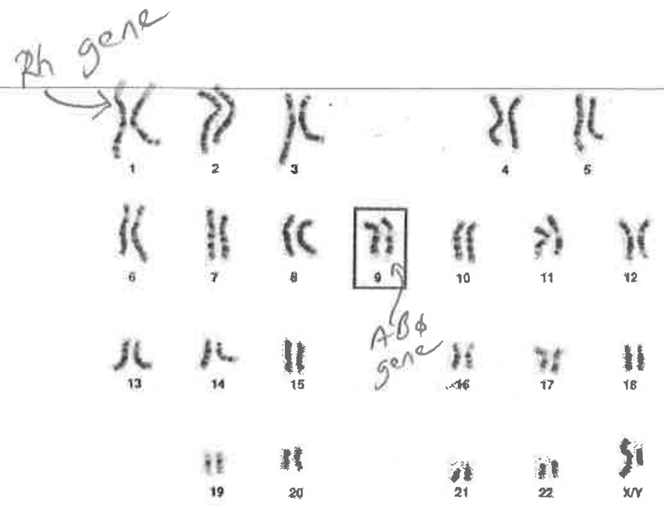
Mr. Woo is unwilling to divorce his wife if the baby is indeed his own. So, he requests tests to determine whether the baby is his child or Mr. Boo's. The tests consist of blood type analysis and DNA analysis. Will the tests reveal that the baby is indeed Baby Woo Hoo? Or, will they reveal that the baby should be named baby Boo Hoo? Will the marriage be saved?

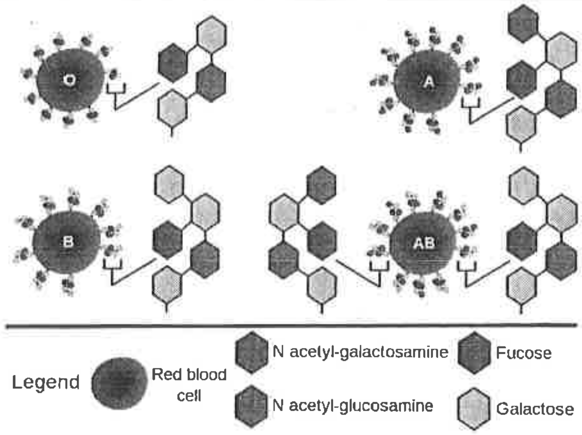
Background:

The gene for blood type is located on chromosome 9 as shown in the somatic cell karyotype below. The gene codes an enzyme, called a glycosyltransferase, whose function is to attach a carbohydrate chain to the outer surface of a protein embedded in the outer leaf of the cell membrane in red blood cells.

The ABO glycosyltransferase gene is multi-allelic, having 2 common co-dominant alleles that code for slightly different external carbohydrate chains attached to a red blood cell membrane protein called antigen h; one co-dominant allele is termed the " A or I^A allele", the other is termed the "B or I^Ballele", while one most common recessive allele, "termed the O or Ø or i allele" is nonfunctional because of a frameshift mutation in the 6^{th} of the gene's seven exons. The recessive allele can also be termed a "nonsense allele" because the frameshift mutations creates in an early stop codon that prevents formation of active enzyme.

Another protein of high importance in determining whether a blood donor and acceptor are compatible is the Dantigen, or Rh, protein. It is coded by several alleles on chromosome 1, some of which are dominant and others are recessive. The recessive alleles are typically deleted to the extend that they code no protein. The protein is a red blood cell membrane transport protein of unknown origin, but it may be protective in preventing blood infections like toxiplasmosis.





ABO Blood type is conveyed by a gene that is both Codominant and multiallelic.

The two dominant alleles are symbolized by I^A or A and I^B or B.

Both dominant alleles code for the same protein, called a glycosyltransferase enzyme, but sequence variation causes the enzyme to add a different sugar to the universal H blood type antigen.

The recessive allele is symbolized by i or ∅. The recessive allele codes defective protein which cannot modify the H antigen by adding a sugar.

The Rh antigen is also called the D antigen. It is also multiallelic, and it is located on chromosome 1.

Human immune systems attack any molecule not normally found in the body prior to birth. One way that the immune system attacks foreign molecules is making antibodies that bind to them and clump them so that defensive cells called macrophages eat them and remove them from the body.

So in a person with the allele I^A the A antigen IS NOT attacked, but B antigen is.

In a person with allele I^B the B antigen IS NOT attacked, but A antigen is.

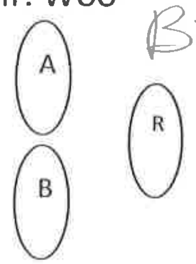
In a person whose genotype is heterozygotic or homozygotic for the dominant D antigen, no antibodies against the antigen are made. But in a person with a homozygous recessive allele phenotype, antibodies that attack the D (Rh) antigen are made. Dd or DD genotypes produce Rh+ phenotypes, and these people can accept Rh+ blood; dd genotypes produce Rh- phenotypes, and these people can donate to Rh+ individuals, but they can not accept Rh+ blood.

In our blood tests, we'll use antibodies that would normally attack the blood antigens to find out if the antigens are present. Then, we'll find the blood type of the person.

10 drops "blood"

10 drops anti A OR Anti B or Anti D (Rh) into marked well.

Tap to mix. Assess as + if clumps have appeared in 10 minutes or – if clumps have not appeared in 10 minutes.

Mr. Woo	Mr. Boo	Mrs Hoo	Baby ?whose?
 B+	O-	A+	AB+

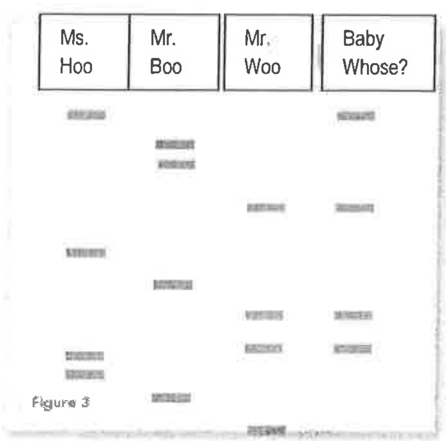


Figure 3

Mrs Hoo phenotype A+

$I^AI^A Rr$

Possible genotypes $I^Ai\ RR$ or $I^AI^A RR$ or $I^Ai\ Rr$

Mr. Boo phenotype O-

Possible genotypes ii rr

Mr. Woo phenotype B+

Possible genotypes $I^Bi\ Rr$, $I^BI^B Rr$, $I^Bi\ RR$, $I^BI^B RR$

Baby whose phenotype AB+

Possible genotypes $I^AI^B RR$ or $I^BI^A Rr$

Complete all possible punnett squares for Rh and A, B, O for:
Mr. Boo X ms. Hoo
Mr. Woo X ms Hoo
Which man, if either, can be the father of baby whose? Explain.

Mr. Boo can not be father, but Mr. Woo can. →

$ii\,rr$ X $I^A i\,Rr$

Boo Hoo

	iR	ir	$I^A R$	$I^A r$
ir	ii Rr	ii rr	$I^A i$ Rr	$I^A i$ rr
ir	↓	↓	↓	↓
ir	↓	↓	↓	↓
ir	↓	↓	↓	↓

$4\,iiRr : 4\,iirr : 4\,I^A iRr : 4\,I^A irr$ genotypic ratio

$4O^+ : 4O^- : 4A^+ : 4A^-$ phenotypic ratio

AB^+ child is not possible

$I^B i\,Rr$ X $I^A i\,Rr$ (AB^+ child is possible 3/16 chance)

Woo Hoo

	$I^B r$	$I^B R$	iR	ir
$I^A R$	$I^A I^B$ Rr	$I^A I^B$ RR	$I^A i$ RR	$I^A i$ Rr
$I^A r$	$I^A I^B$ rr	$I^B I^A$ Rr	$I^A i$ Rr	$I^A i$ Rr
iR	$I^B i$ Rr	$I^B i$ RR	ii RR	ii Rr
ir	$I^B i$ rr	$I^B i$ Rr	ii Rr	ii rr

g. ratio
- $iirr$ I
- $I^A I^B Rr$ II
- $I^A I^B RR$ I
- $I^A i\,RR$ I
- $I^A i\,Rr$ III
- $I^A I^B rr$ I
- $I^B i\,Rr$ I
- $I^B i\,RR$ II
- $I^B i\,rr$ I
- $ii\,Rr$ II

phen ratio $3AB^+ : 1AB^- : 4A^+ : 4B^+ : 1B^- : 2O^+ : 1O^-$

Name: ______________________________

Non-Mendelian FA

GradeCam ID:

Form Identifier – Do not mark

Non-Mendelian Inheritance Formative Assessment

1. **SIMPLE DOMINANCE.** In bunnies, brown fur is dominant and white fur is recessive. A heterozygous bunny is crossed with a white bunny. Fill in the Punnett Square (1pt) and answer the questions below.

Parent Genotypes: Bb x bb (1 pt)

	B	b
b	Bb	bb
b	Bb	bb

a. What is the probability of a white bunny in the offspring? (1 pt)

50%

b. What is the genotypic ratio of the offspring? (1 pt)

2 Bb : 2 bb

c. What is the phenotypic ratio of the offspring? (1 pt)

2 Brown : 2 white

2. **INCOMPLETE DOMINANCE.** In snapdragon flowers, Red flower color is incompletely dominant and white flower color is recessive. Two pink flowers are crossed. Fill in the Punnett Square (1pt) and answer the questions below.

Parent Genotypes: Rr x Rr (1 pt)

	R	r
R	RR	Rr
r	Rr	rr

a. What is the probability of a red flower in the offspring? (1 pt)

25%

b. What is the genotypic ratio of the offspring? (1 pt)

1 RR : 2 Rr : 1 rr

c. What is the phenotypic ratio of the offspring? (1 pt)

1 Red : 2 Pink : 1 white

3. **CO-DOMINANCE**. Black and white colored feathers are co-dominant in chickens. A black chicken is crossed with a speckled chicken. Fill in the Punnett Square (1pt) and answer the questions below.

Parent Genotypes: BB x BW (1 pt)

	B	B
B	BB	BB
W	BW	BW

a. What is the probability of a white chicken in the offspring? (1 pt)

0%

b. What is the genotypic ratio of the offspring? (1 pt)

2BB : 2BW

c. What is the phenotypic ratio of the offspring? (1 pt)

2 BLACK : 2 SPECKLED

4. **MULTIPLE ALLELES**. In human blood type, type A (I^A) and type B (I^B) are co-dominant. Type O blood is recessive (i). Mr. Mallin has type O blood and Mrs. Mallin is heterozygous for Type B blood. Fill in the Punnett Square (1pt) and answer the questions below.

Parent Genotypes: ii x $I^B i$ (1 pt)

	I^B	i
i	$I^B i$	ii
i	$I^B i$	ii

a. What is the probability of a blood type A in the offspring? (1 pt)

0%

b. What is the genotypic ratio of the offspring? (1 pt)

2 $I^B i$: 2 ii

c. What is the phenotypic ratio of the offspring? (1 pt)

2 Type B : 2 Type O

Level 3 Challenge: Dog Breeder's Dilemma – Deaf Dalmatians

simple dominance

Your neighbor breeds Dalmatian dogs, and she asks for your help since your mother has been bragging that you got a perfect score on your genetics test. Your neighbor is concerned because deafness is quite common in Dalmatian dogs. She has two male dogs that she wants to use for breeding with some of her female dogs. The male dogs can hear, but she does not want to use any dog for breeding if he could possibly father deaf puppies.

1. You assume that deafness is due to a recessive allele for a single gene. What are the possible genotypes for the male dogs that can hear? (Use **d** for the recessive allele for deafness and **D** for the allele for normal hearing.) DD = Normal dd = deaf
Dd = Normal

2. To test whether each of the male dogs is heterozygous or homozygous, you recommend that your neighbor mate each male dog with a specific type of female dog. What type of female dog should your neighbor use for this test? What would this female dog's phenotype and genotype be? A deaf dog (dd) crossed with heterozygous (Dd) would produce 50% deaf dogs; no deaf dogs when crossed with homozygous (DD).

3. Draw the appropriate Punnett Squares to illustrate how this test would determine whether each of your neighbor's male dogs is heterozygous or homozygous. In the Punnett squares, circle any offspring that would be deaf.

	D	D
d	Dd	Dd
d	Dd	Dd

4/4 normal (Dd)
0/4 deaf (dd)

or

	D	d
d	Dd	dd
d	Dd	dd

2 Normal (Dd)
2 deaf (dd)

4. Your neighbor follows your advice and reports the results shown in the first column of the table. Complete the middle and last columns of the table to show the advice you would give to your neighbor.

Outcome of mating	Should the owner use this dog for breeding purposes? Why or why not?	How confident are you of this conclusion?
First father: 5 puppies, 1 deaf	No. The father is heterozygous.	100%. the father had to have a recessive allele to have a deaf pup.
Second father: 6 puppies, 0 deaf	Yes. The father is homozygous.	80%, this could still be result of a heterozygous cross.

You are proud of your work as a genetics advisor and you show this table to your teacher, hoping that she may give you some extra credit in your biology course. She responds, "Oh no! I hope you didn't give your neighbor a guarantee on your advice."

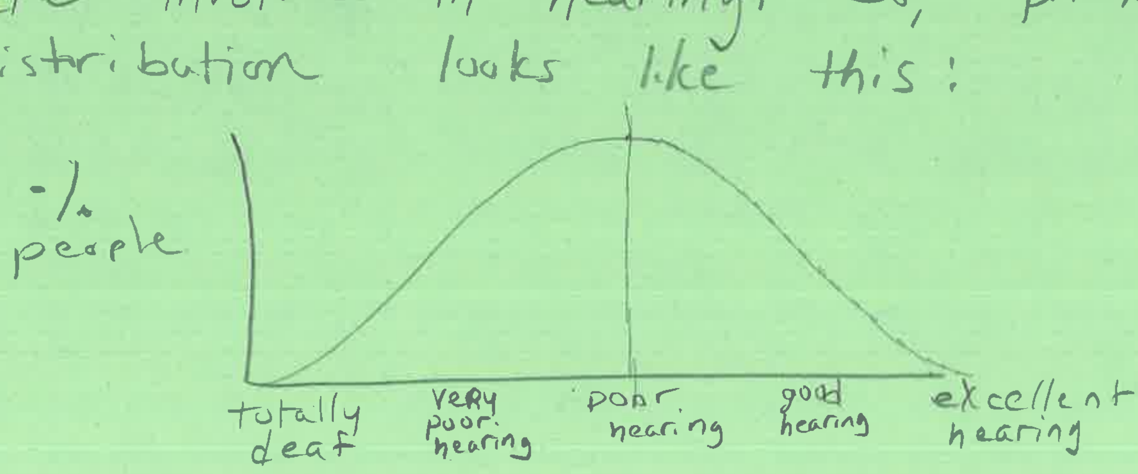
You are upset and ask her what is wrong. She explains that biologists have discovered that the inheritance of deafness is very complex and involves more than one gene. In humans there are at least 40 different genes that can result in deafness by causing defects in the development or function of different parts of the ear or nervous system. Biologists still have not figured out the genes responsible for deafness in Dalmatians, but they know that more than one gene is involved. Because the genetics is complex and not well understood, careful breeding can reduce the chance of deafness but not eliminate the possibility of deaf puppies.

You are still feeling upset, and you ask your teacher, "Do you mean that all the stuff you taught us about Mendel and genetics isn't really true?"

5. How should she respond?

It depends! Some traits do work like Mendel's peas. But not all. There are many patterns of inheritance.

In humans, deafness is polygenic since more than 40 genes are involved in hearing. So, phenotypic distribution looks like this:



Level 4 Extension Problems:
EPISTASIS

The success of Gregor Mendel's classic studies of the pea plant were a result, in part, of the traits that Mendel chose to study. It turns out that each characteristic Mendel followed in his crosses was influenced by a single gene. In addition, each of the genes that he studied had only a limited effect.

We know now that many traits result from interactions among genes. Such interactions are called epistasis. For example, epistasis is common among genes responsible for the color of fur or skin in mammals.

Consider color variation in Labrador retrievers. The different colors are from variation in the amount and distribution of melanin, a brownish-black pigment. The alleles of one specify an enzyme required to produce melanin. Expression of the allele **B** (black) has a more pronounced effect and is dominant to **b** (brown). Alleles of a different gene control the extent to which molecules of melanin are deposited in a Labrador's hairs. The allele **E** permits full expression of the coat color, while two recessive alleles (**ee**) **reduces expression** of the coat color. Yellow labs have less pigment because they are homozygous recessive for the epistasis gene.

Phenotype	**Possible Genotypes (for coat color & epistasis gene)**
Black	BBEE, BBEe, BbEE, BbEe
Brown	bbEe, BBee, Bbee
Yellow	bbee

Try these problems... (Hint: You have to do a dihybrid cross!!)

1) You are a Labrador breeder and have a female black lab with a genotype of BbEE and cross it with a yellow lab with a genotype of bbee. What are the genotypic ratios of the offspring? Phenotypic ratios?

BbEE x bbee

	BE	BE	bE	bE
be	BbEe	BbEe	bbEe	bbEe
be	↓	↓	↓	↓
be				
be				

1 BbEe : 1 bbEe

1 Black : 1 Brown

2) A yellow lab (bbee) mates with a mates with a brown lab who is heterozygous for the epistasis gene. What are the genotypic ratios of the offspring? Phenotypic ratios? bbee × bbEe

	bE	be	bE	be
be	bbEe	bbee	bbEe	bbee
be	↓	↓	↓	↓
be	↓	↓	↓	↓
be	↓	↓	↓	↓

1 bbEe : bbee

1 Brown : 1 yellow

3) You have an order for a litter of all yellow labs (bbee). Your male black lab, Charlie, is heterozygous for coat color (Bb) and heterozygous for epistasis (Ee). Is it possible for your male to produce a litter of all yellow labs? If so, what would the genotype of the female dog need to be? Show your work.

BbEe × BbEe, bbEe, Bbee or bbee

	BE	Be	bE	be
BE	BBEE	BBEe	BbEE	BbEe
Be	BBEe	BB	BbEe	Bbee
bE	BbEE	Bb	bbEE	bbEe
be	BbEe	Bb	bbEe	(bbee)

☆ bbee would be best, but other possibilities could work

the female can Not be homozygous dominant for either coat or epistasis. she needs to be at least heterozygous for both but this would have low efficacy.

4) In sweet peas, purple flower color (P) is dominant over white (p), but there is also a control gene such that if the plant has a "C", the purple has "permission" to express itself. If the plant is "cc," the purple does not "have permission" to express itself and the flower will be white anyway. If the female parent is PPCC and the male parent is ppcc, what would the F_1 genotypic and phenotypic ratios be? How about the F_2 genotypic and phenotypic ratios? PPCC × ppcc

F_1 would be heterozygous for color & epistasis.

F_2

	PC	Pc	pC	pc
PC	PPCC	PPCc	PpCC	PpCc
Pc	PPCc	PPcc	PpCc	Ppcc
pC	PpCC	PpCc	ppCC	ppCc
pc	PpCc	Ppcc	ppCc	ppcc

F_2: 1 PPCC : 2 PPCc : 1 PPcc : 2 PpCC : 4 PpCc : 2 Ppcc : 1 ppCC : 2 ppCc : 1 ppcc

F_2 7 Purple : 7 White