Name ______________________________

Genetics Practice Problems

1. For each genotype below, indicate whether it is heterozygous **(He)** or homozygous **(Ho)**

AA Ho	Ee He	Ii He	Mm He
Bb He	ff Ho	Jj He	nn Ho
Cc He	GG Ho	kk Ho	OO Ho
Dd He	HH Ho	Ll He	Pp He

2. For each of the **genotypes** below determine what **phenotypes** would be possible.

Purple flowers are dominant to white
PP Purple
Pp Purple
pp white

Brown eyes are dominant to blue
BB Brown
Bb Brown
bb Blue

Round seeds are dominant to wrinkled
RR Round
Rr Round
rr wrinkled

Bobtails are recessive (to long tails)
TT Long
Tt Long
tt Bob

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

Straight hair is dominant to curly
SS straight
Ss straight
ss curly

Tail spikes are dominant to plain tails
S_ spikes
Ss spikes
ss plain

4. Set up the Punnet squares for each of the crosses listed below. **Round seeds are dominant to wrinkled.**

Rr x rr

	R	r
r	Rr	rr
r	Rr	rr

What percentage of the offspring will be round? 50%

Rr x Rr

	R	r
R	RR	Rr
r	Rr	rr

What percentage of the offspring will be round? 75%

RR x Rr

	R	R
R	RR	Rr
r	Rr	Rr

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%

	T	T
t	Tt	Tt
t	Tt	Tt

6. A Tt plant is crossed with a Tt plant. What percentage of the offspring will be short? 25% What percentage is tall? 75%

	T	t
T	TT	Tt
t	Tt	tt

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%

	R	r
R	RR	Rr
R	RR	Rr

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%
   What is the genotype of all of the offspring? Rr

	R	R
r	Rr	Rr
r	Rr	Rr

9. **In pea plants purple flowers are dominant to white flowers.** If two white flowered plants are cross, what percentage of their offspring will be white flowered? 100%

	p	p
p	pp	pp
p	pp	pp

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? 50%

	P	p
p	Pp	pp
p	Pp	pp

11. Two plants, both heterozygous for the gene that controls flower color are crossed. What percentage of their offspring will have purple flowers? 75%
    What percentage will have white flowers? 25%

	P	p
P	PP	Pp
p	Pp	pp

12. In guinea pigs, the **allele for short hair is dominant.**
    What genotype would a heterozygous short haired guinea pig have? Ss
    What genotype would a purebreeding short haired guinea pig have? SS
    What genotype would a long haired guinea pig have? ss

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%
    What is the genotype of the offspring? Ss

	s	s
S	Ss	Ss
S	Ss	Ss

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%

	S	s
S	SS	Ss
s	Ss	ss

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? Ss x Ss **Show the cross to prove it!**

	S	s
S	SS	Ss
s	Ss	ss

Dihybrid Cross Worksheet

1. Set up a punnett square using the following information:
   - Dominate allele for tall plants = D
   - Recessive allele for dwarf plants = d
   - Dominate allele for purple flowers = W
   - Recessive allele for white flowers = w
   - Cross a homozygous dominate parent (DDWW) with a homozygous recessive parent (ddww)

	DW	DW	DW	DW
dw	DdWw	DdWw	DdWw	DdWw
dw	DdWw	DdWw	DdWw	DdWw
dw	DdWw	DdWw	DdWw	DdWw
dw	DdWw	DdWw	DdWw	DdWw

2. Using the punnett square in question #1:
   a. What is the probability of producing tall plants with purple flowers? 100% 16/16
   Possible genotype(s)? DdWw
   b. What is the probability of producing dwarf plants with white flowers? 0%
   Possible genotype(s)? None
   c. What is the probability of producing tall plants with white flowers? 0%
   Possible genotype(s)? None
   d. What is the probability of producing dwarf plants with purple flowers? 0%
   Possible genotype(s)? None

3. Set up a punnett square using the following information:
   - Dominate allele for black fur in guinea pigs = B
   - Recessive allele for white fur in guinea pigs =b
   - Dominate allele for rough fur in guinea pigs = R
   - Recessive allele for smooth fur in guinea pigs = r
   - Cross a heterozygous parent (BbRr) with a heterozygous parent (BbRr)

	BR	Br	bR	br
BR	BBRR	BBRr	BbRR	BbRr
Br	BBRr	BBrr	BbRr	Bbrr
bR	BbRR	BbRr	bbRR	bbRr
br	BbRr	Bbrr	bbRr	bbrr

4. Using the punnett square in question #3:
   a. What is the probability of producing guinea pigs with black, rough fur? 9/16
   Possible genotype(s)? BBRR, BBRr, BbRR, BbRr
   b. What is the probability of producing guinea pigs with black, smooth fur? 3/16
   Possible genotype(s)? BBrr, Bbrr
   c. What is the probability of producing guinea pigs with white, rough fur? 3/16
   Possible genotype(s)? bbRr, bbRR
   d. What is the probability of producing guinea pigs with white, smooth fur? 1/16
   Possible genotype(s)? bbrr

5. Set up a punnett square using the following information:

- Dominate allele for purple corn kernels = R
- Recessive allele for yellow corn kernels = r
- Dominate allele for starchy kernels = T
- Recessive allele for sweet kernals = t
- Cross a homozygous dominate parent with a homozygous recessive parent

	RT	RT	RT	RT
rt	RrTt	RrTt	RrTt	RrTt
rt	RrTt	RrTt	RrTt	RrTt
rt	RrTt	RrTt	RrTt	RrTt
rt	RrTt	RrTt	RrTt	RrTt

6. Using the punnett square in question #5:
   a. What is the probability of producing purple, starchy corn kernels? 100%

      Possible genotype(s)? RrTt
   b. What is the probability of producing yellow, starchy corn kernels? 0%

      Possible genotype(s)? None
   c. What is the probability of producing purple, sweet corn kernels? 0%

      Possible genotype(s)? None
   d. What is the probability of producing yellow, sweet corn kernels? 0%

      Possible genotype(s)? None

7. Set up a punnett square using the following information:

- Dominate allele for normal coat color in wolves = N
- Recessive allele for black coat color in wolves = n
- Dominant allele for brown eyes = B
- Recessive allele for blue eyes = b
- Cross a heterozygous parent with a heterozygous parent

	NB	Nb	nB	nb
NB	NNBB	NNBb	NnBB	NnBb
Nb	NNBb	NNbb	NnBb	Nnbb
nB	NnBb	NnBb	nnBB	nnBb
nb	NnBb	Nnbb	nnBb	nnbb

8. Using the punnett square in question #7:
   a. What is the probability of producing a wolf with a normal coat color with brown eyes? 9/16.

      Possible genotype(s)? NNBB, NNBb, NnBB, NnBb
   b. What is the probability of producing a wolf with a normal coat color with blue eyes? 3/16

      Possible genotype(s)? NNbb, Nnbb
   c. What is the probability of producing a wolf with a black coat with brown eyes? 3/16

      Possible genotype(s)? nnBb, nnBB
   d. What is the probability of producing a wolf with a black coat with blue eyes? 1/16

      Possible genotype(s)? nnbb

9. A tall pea plant with **terminal** flowers (flowers on the ends of the stems) is crossed with a **short** plant that has axial flowers. All 72 offspring are tall with axial flowers. This is a dihybrid cross with the height and flower position traits showing independent assortment.

   a. Name the dominant and recessive alleles. (hint see textbook pg. 262)
   Dominant = Tall and Axial Recessive = Short and Terminal
   b. Give the genotypes of the parents and offspring in this cross.
   TTaa X ttAA
   c. Predict the F_2 offspring when the tall-axial F_1's are allowed to self pollinate.
   TtAa x TtAa = 9/16 Tall & Axial 3/16 Tall & Terminal 3/16 Short & Axial 1/16 Short & terminal

10. Suppose a white, straight haired guinea pig mates with a brown, curly-haired animal. All five babies in their first litter have brown fur, but three are curly and two have straight hair. The second litter consists of six more brown offspring, where two are curly and four are straight haired.

   a. Assuming curly is dominant to straight, what are the genotypes of the parents and the offspring?
   bbcc X BBCc → BbCc , Bbcc
   b. What is the probability of getting two female guinea pigs with straight hair in a row?
   1/2 x 1/2 x 1/2 x 1/2 = 1/16

11. About 70% of Americans get a bitter taste from the substance called phenylthiocarbamide (PTC). It is tasteless to the rest. The "taster" allele is dominant to non-taster. Also, normal skin pigmentation is dominant to albino. A normally pigmented woman who is taste-blind for PTC has an albino-taster father. She marries an albino man who is a taster, though the man's mother is a non-taster. Show the expected offspring of this couple.
   Nntt X nnTt → NnTt nnTt
   Nntt nntt

12. In pigeons the checkered pattern is caused by a dominant allele. A plain (non-checkered) pattern is recessive. Red color is also caused by a dominant allele and brown color by a recessive allele.

   a. Show the expected offspring of a cross between a homozygous checkered red bird and a plain brown one. Carry out this cross through the F_2 generation. 9/16 Checkered Red 3/16 Checkered Brown
   CcRr → 9:3:3:1 ratio 3/16 Noncheckered Red 1/16 Noncheckered Brown
   b. Carry out to the F_2 generation a cross between a homozygous plain red bird and its homozygous checkered brown mate. ccRR x CCrr → CcRr

   c. A plain brown female pigeon laid five eggs. The young turned out to be: 2 plain red, 2 checkered red, and 1 checkered brown. Describe the father pigeon. Give the genotypes of all birds in this cross. Could any other types of offspring have been produced by this pair?

   ccrr x CcRr
   M F

   Yes, Plain brown.

   ccRr
   CcRr
   Ccrr
   Offspring

PTC-taster- TT, Tt Non-PTC taster – tt Hitchhikers thumb- HH, Hh Straight thumb – hh Hair on mid-digit – MM, Mm No hair on mid-digit- mm	Attached earlobes- EE, Ee Free earlobes – ee Straight pinky- PP, Pp Bent pinky- pp Widow's peak- WW, Ww No widow's peak- ww	Can roll tongue- RR, Rr Can't roll tongue - rr

Dihybrid Crosses. Set up the crosses using the rules and the letters from the other page.

1. If a woman who is a non-PTC taster (recessive) with heterozygous hitchhikers thumb has children with a man who is a heterozygous PTC taster with straight thumbs (recessive), what is the probability of them having each of the following types of children? (Fill in the Punnett Square and the blanks).

   Parents' genotypes ttHh X Tthh

   a. How many PTC taster, Hitchhikers thumb 4/16
   b. How many PTC taster, straight thumb 4/16
   c. How many Non-PTC taster, Hitchhikers thumb 4/16
   d. How many Non- PTC taster, straight thumb 4/16
   e. What is the phenotypic ratio? 4:4:4:4

	Th	Th	th	th
tH	TtHh	TtHh	ttHh	ttHh
th	Tthh	Tthh	tthh	tthh
tH	TtHh	TtHh	ttHh	ttHh
th	Tthh	Tthh	tthh	tthh

2. If a woman who has no hair on her mid-digit (recessive)and is homozygous attached earlobes (dominant) has children with a man who has hair on his mid-digit and has attached earlobes (heterozygous for both traits), what is the probability of them having each of the following types of children? (Fill in the Punnett Square and the blanks).

   Parents' genotypes mmEE X MmEe

   a. How many hair, attached earlobes 8/16
   b. How many hair, not attached earlobes 0/16
   c. How many hairless, attached earlobes 8/16
   d. How many hairless, not attached earlobes 0/16
   e. What is the phenotypic ratio? 8:8

	ME	Me	mE	me
mE	MmEE	MmEe	mmEE	mmEe
mE	MmEE	MmEe	mmEE	mmEe
mE	MmEE	MmEe	mmEE	mmEe
mE	MmEE	MmEe	mmEE	mmEe

3. John Doe and Jane Doe want to have children and are thinking about how their childrens' hands might look. What would their children look like if they are both heterozygous for straight pinky and hitchhikers thumb? (Fill in the Punnett Square and the blanks).

   Parents' genotypes PpHh X PpHh

   a. Straight pinky, hitchhikers thumb 9/16
   b. Straight pinky, Straight thumbs 3/16
   c. bent pinky, hitchhikers thumb 3/16
   d. bent pinky, Straight thumbs 1/16
   e. What is the phenotypic ratio? 9:3:3:1

	PH	Ph	pH	ph
PH	PPHH	PPHh	PpHH	PpHh
Ph	PPHh	PPhh	PpHh	Pphh
pH	PpHH	PpHh	ppHH	ppHh
ph	PpHh	Pphh	ppHh	pphh

4. Dohn Joe and Dane Joe want to have children and are thinking about how their childrens' hair line and tongues will turn out. They are both circus performers and want their children to follow in their footsteps. Their circus only accepts people with a Widow's Peak and who can roll their tongues. What would their children look like if Dohn is heterozygous for both Widow's peak and tongue rolling, and Dane is homozygous dominant for Widow's peak and heterozygous for tongue rolling? (Fill in the Punnett Square and the blanks).

Parents' genotypes WwRr X WWRr

a. Widow's Peak, Tongue Roller 12/16

b. Widow's Peak, non tongue roller 4/16

c. Straight hair line, Tongue Roller 0/16

d. Straight hair line, non tongue roller 0/16

e. What is the phenotypic ratio? 12:4

f. What are the chances of their child being able to join the circus?

75%

	WR	Wr	wR	wr
WR	WWRR	WWRr	WwRR	WwRr
Wr	WWRr	WWrr	WwRr	Wwrr
WR	WWRR	WWRr	WwRR	WwRr
Wr	WWRr	WWrr	WwRr	Wwrr

Investigation
6

Who Gets the Money?

Purpose

To solve a mystery involving genetics.

Concepts

- Punnett squares
- Incomplete dominance
- Sex-linked inheritance
- Monohybrid cross
- Codominance

Background

This story appeared in the local paper recently:

> Mr. and Mrs. John Jones died in a tragic farm accident when the tractor they were riding on rolled over in a ditch. Authorities found one million dollars hidden in a feed bid in the chicken coop. The couple is known to have a son, from whom they are estranged. This man is the sole heir to the Jones fortune.

Five men show up, each claiming to be the couples' long lost son who had run away to become a sheep-herder. You are called in as a genetics expert to decide who is the rightful heir. This mystery will be solved in three parts.

Procedure

Complete Parts One, Two, and Three of the Who Gets the Money? Worksheet as directed by your instructor.

Safety

There are no particular safety concerns for this activity, but follow all normal laboratory safety rules.

Name: ____

Who Gets the Money? Worksheet

Part One: Monohybrid Cross

Brown eyes are dominant over blue eyes, free earlobes are dominant over attached earlobes.

Mr. Jones	Heterozygous, free earlobes, and homozygous brown-eyed.
Mrs. Jones	Heterozygous, free earlobes, and heterozygous brown-eyed.
Carl	Homozygous brown-eyed, and attached earlobes.
Ray	Homozygous free earlobes, blue-eyed.
Dale	Heterozygous free earlobes, homozygous brown-eyed.
Earl	Heterozygous free earlobes, and heterozygous brown-eyed.
Robert	Homozygous free earlobes, blue-eyed.

In the space below, draw two Punnett Squares showing the possible offspring of Mr. and Mrs. Jones: one for eye color and one for earlobes.

	F	f
F	FF	Ff
f	Ff	ff

	B	B
B	BB	BB
b	Bb	Bb

Write each person's genotypes in the chart below.

Person	Eye Color	Earlobes
Mr. Jones	BB	Ff
Mrs. Jones	Bb	Ff
Carl	BB	ff
Ray	bb	FF
Dale	BB	Ff
Earl	Bb	Ff
Robert	bb	FF

Which men can be eliminated by these traits? Explain your reasoning for each man.

Ray - because The Jones' cannot have a blue eyed offspring

Robert - Blue eyed offspring not possible

Name: ______________________________

Who Gets the Money? Worksheet

Part Two: Co-dominance and Incomplete dominance

Now that Rae & Rob have been eliminated, lawyers order blood tests to try to prove their claims. The lawyers have also done some research and read that hair texture is inherited.

Type A and type B blood are co-dominant over type O.
Rh+ blood is dominant over Rh- blood.
Hair texture exhibits incomplete dominance. Homozygous dominants (HH) have curly hair. Homozygous recessives (hh) have straight hair. Heterozygotes (Hh) have wavy hair.

Mr. Jones	Homozygous type A blood, heterozygous Rh+, straight hair.
Mrs. Jones	Heterozygous type B blood, homozygous Rh+, wavy hair.
Carl	Heterozygous type A blood, heterozygous Rh+, wavy hair.
Dale	Heterozygous type A blood, homozygous Rh+, wavy hair.
Earl	Type O blood, Rh-, straight hair.

In the space below, draw three Punnett Squares showing the possible offspring of Mr. and Mrs. Jones: for blood type, Rh type, and hair textures.

	I^A	I^A
I^B	I^AI^B	I^AI^B
i	I^Ai	I^Ai

	+	-
+	++	+-
+	++	+-

	h	h
H	Hh	Hh
h	hh	hh

Write each person's genotypes in the chart below.

Person	Blood Type	Rh Type	Hair Texture
Mr. Jones	AA	+ -	hh
Mrs. Jones	BO	+ +	Hh
Carl	AO	+ -	Hh
Dale	AO	+ +	Hh
Earl	OO	- -	hh

Which men can be eliminated now? Justify your answers for each man.

Earl because he has O blood and Rh-.

Name: ______________________________

Who Gets the Money? Worksheet

Part Three: Sex-linked Inheritance

We're down to just Carl & Dale. The lawyer now orders that a vision test be performed to test for red-green color blindness.

Mr. Jones	Color blind
Mrs. Jones	Homozygous for normal vision
Carl	Color blind
Dale	Normal vision

In the space below, draw a Punnett Squares showing the possible offspring of Mr. and Mrs. Jones for color blindness.

	X^c	Y
X^C	X^CX^c	X^CY
X^C	X^CX^c	X^CY

Write the genotypes of the persons in the table below:

Person	Vision
Mr. Jones	X^cY
Mrs. Jones	X^CX^C
Carl	X^c
Dale	X^CY

SO: WHO GETS THE MONEY? (Don't forget to justify your answer!)

Dale - he is not colorblind and Mrs. Jones can only have normal vision offspring

Name: ______________________________ Date: ________ Period: ____

Genetics: Punnett Squares Practice

Most genetic traits have a stronger, dominant allele and a weaker, recessive allele. In an individual with a heterozygous genotype, the dominant allele shows up in the offspring and the recessive allele gets covered up and doesn't show; we call this **complete dominance**.
However, some alleles don't completely dominate others. In fact, some heterozygous genotypes allow both alleles to partially show by blending together how they are expressed; this is called **incomplete dominance.** Other heterozygous genotypes allow both alleles to be completely expressed at the same time like spots or stripes; this is called **codominance**. Examples of each are listed below.
Write what each type would be if they were heterozygous.

1. Complete dominance = If a Red (RR) and White flower (rr) were crossbred, resulting in 100% Rr, what phenotype would been seen according to the rules of COMPLETE dominance?

   Red

2. Incomplete dominance = If a Red (RR) and White flower (rr) were crossbred, resulting in 100% Rr, what phenotype(s) would been seen according to the rules of IN-complete dominance?

   Pink

3. Codominance = If a Red (RR) and White flower (WW) were crossbred, resulting in 100% RW, what phenotype(s) would been seen according to the rules of CO-dominance?

   Red and white

Incomplete dominance practice Problems

4-6. Snapdragons are incompletely dominant for color; they have phenotypes red, pink, or white. The red flowers are homozygous dominant, the white flowers are homozygous recessive, and the pink flowers are heterozygous. Give the genotypes for each of the phenotypes, using the letters "R" and "r" for alleles:

a. Red snapdragon genotype: RR
b. Pink snapdragon genotype: WW
c. White snapdragon genotype: RW

Show genetic crosses between the following snapdragon parents, using the punnett squares provided, and record the genotypic and phenotypic %s below:

a. pink x pink

	R	W
R	RR	RW
W	RW	WW

Genotypic %: 1:2:1
Phenotypic %: 1:2:1

b. red x white

	R	R
W	RW	RW
W	RW	RW

Genotypic %: 100%
Phenotypic %: 100%

c. pink x white

	R	W
W	RW	WW
W	RW	WW

Genotypic %: 1:1
Phenotypic %: 1:1

7-9. In horses, some of the genes for hair color are incompletely dominant. Genotypes are as follows: brown horse are BB, white horses are bb and a Bb genotype creates a yellow-tannish colored horse with a white mane and tail, which is called "palomino". Show the genetic crosses between the following horses and record the genotypic and phenotypic percentages:

a. brown x white

	B	B
W	BW	BW
W	BW	BW

Genotypic %: 100%
Phenotypic %: 100%

b. brown x palomino

	B	B
B	BB	BB
W	BW	BW

Genotypic %: 1:1
Phenotypic %: 1:1

c. palomino x palomino

	B	W
B	BB	BW
W	BW	WW

Genotypic %: 1:2:1
Phenotypic %: 1:2:1

10. Can palominos be considered a purebred line of horses? Why or why not?

No, crossing palominos will result in Brown, white, and palominos

11. Which two colors of horse would you want to breed if you wanted to produce the maximum numbers of palomi in the shortest amount of time?

Brown x white

12. In Smileys, eye shape can be starred (SS), circular (CC), or a circle with a star (CS). Write the genotypes for the pictured phenotypes

CC   SS   CS

13. Show the cross between a star-eyed and a circle eyed.
What are the phenotypes of the offspring? Circle w/ star
What are the genotypes? CS

	S	S
C	CS	CS
C	CS	CS

14. Show the cross between a circle-star eyed, and a circle eyed.
How many of the offspring are circle-eyed? 50%
How many of the offspring are circle-star eyed? 50%

	C	S
C	CC	CS
C	CC	CS

15. Show the cross between two circle-star eyed.
How many of the offspring are circle-eyed? 25%
How many of the offspring are circle-star eyed? 50%
How many are star eyed? 25%

	C	S
C	CC	CS
S	CS	SS

Codominance Worksheet (Blood types)

Name________________________
Period ___________ Date ________

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).

Blood Type (Phenotype)	Genotype	Can donate blood to:	Can receive blood from:
O	ii (OO)	A,B,AB and O (universal donor)	O
AB	I^AI^B	AB	A,B,AB and O (universal receiver)
A	I^AI^A or I^Ai (I^AO)	AB, A	O,A
B	I^BI^B or I^Bi (I^BO)	AB,B	O,B

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

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)*

B

	I^B	I^B
I^O	I^BI^O	I^BI^O
I^O	I^BI^O	I^BI^O

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

50% A 50% B

	I^O	I^O
I^A	I^AI^O	I^AI^O
I^B	I^BI^O	I^BI^O

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 I^OI^O
   b. Mrs. Essy must have the genotype I^AI^O because Mark has blood type I^OI^O
   c. Luke cannot be the child of these parents because neither parent has the allele B.

	I^O	I^O
I^A	I^AI^O	I^AI^O
I^O	I^OI^O	I^OI^O

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: I^OI^O
   b. Father's genotype: I^AI^B
   c. Baby's genotype: I^BI^O or I^BI^B
   d. Punnett square showing all possible genotypes for children produced by this couple.
   e. Was the baby switched? No

	A	B
O	AO	BO
O	AO	BO

6. Two other parents think their baby was switched at the hospital. Amy the mother has blood type "A," Linville the father has blo type "B," and Priscilla the baby has blood type "AB."

	A	A
B	AB	AB
O	AO	AO

a. Mother's genotype: I^AI^A or I^AI^O

b. Father's genotype: I^BI^B or I^BI^O

c. Baby's genotype: I^AI^B

d. Punnett square that shows the baby's genotype as a possibility

e. Could the baby actually be theirs? Yes

7. Based on the information in this table, which men **could not** be the father of the baby?

(hint... look at the baby's blood type only...) The mailman
You can use the Punnett square if you need help figuring it out. The waiter

Name	Blood Type
Mother	Type A
Baby	Type B
The mailman	Type O
The butcher	Type AB
The waiter	Type A
The cable guy	Type B

	O	O
A	AO	AO
O	OO	OO

8. The sister of the mom above also had issues with finding out who the father of her baby was. She had the state take a blood test of potential fathers. Based on the information in this table, why was the baby taken away by the state after the test?

(hint... look at the baby's blood type only...) Mother has neither A nor B to give to child

Name	Blood Type
Mother	Type O
Baby	Type AB
Bartender	Type O
Guy at the club	Type AB
Cabdriver	Type A
Flight attendant	Type B

BLOOD TYPE & INHERITANCE

12 Points
2 pts. each

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

	I^O	I^O
I^O	I^OI^O	I^OI^O
I^O	I^OI^O	I^OI^O

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

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

	I^A	I^A
I^B	I^AI^B	I^AI^B
I^B	I^AI^B	I^AI^B

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

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

	I^A	I^O
I^B	I^AI^B	I^BI^O
I^O	I^AI^O	I^OI^O

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

5. Father is type O, Mother is type AB

	I^O	I^O
I^A	I^AI^O	I^AI^O
I^B	I^BI^O	I^BI^O

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

6. Father and Mother are both type AB

	A	B
A	AA	AB
B	AB	BB

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

Analyzing Simple Pedigrees:

A pedigree is just like a family tree except that it focuses on a specific genetic trait. A pedigree usually only shows the phenotype of each family member. With a little thought, and the hints below, you may be able to determine the genotype of each family member as well!

Hints for analyzing pedigrees:

1) If the individual is homozygous recessive, then both parents MUST have at least one recessive allele (parents are heterozygous or homozygous recessive).

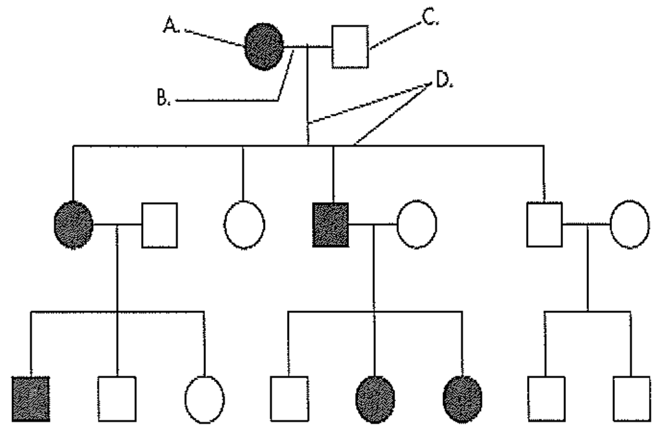
2) If an individual shows the dominant trait, then at least one of the parents MUST have the dominant phenotype. This one will be pretty obvious when you look at the pedigree.

3) If both parents are homozygous recessive, then ALL offspring will be homozygous recessive.

NOTE: In a pedigree, the trait of interest can be *dominant or recessive.* The majority of harmful genetic conditions are only seen when an individual is homozygous recessive - examples of conditions caused by recessive **alleles include cystic fibrosis (a disease of the secretory glands, including those that make mucus and sweat), Falconi anemia (a blood disorder), albinism (a lack of pigmentation), and phenylketonuria (a metabolic disorder). Some genetic conditions are caused by dominant alleles (and may therefore be expressed in homozygous dominant or heterozygous individuals)- examples of conditions caused by dominant alleles include polydactyly (presence of extra fingers), achondroplasia (a type of dwarfism), neurofibromatosis (a nervous disorder), and a disease known as familial hypercholesterolemia in which affected individuals suffer from heart disease due to abnormally high cholesterol levels**

Human Pedigrees

For Questions 1-9, use the pedigree chart shown below. Some of the labels may be used more than once.



C 1. A male

A 2. A female

B 3. A marriage

A 4. A person who expresses the trait

C 5. A person who does not express the trait

D 6. A connection between parents and offspring

3 7. How many generations are shown on this chart?

Assuming the chart above is tracing the dominant trait of "White Forelock (F)" through the family. F is a tuft of white hair on the forehead.

Ff 8. What is the most likely genotype of individual "A"? (FF, Ff or ff?)

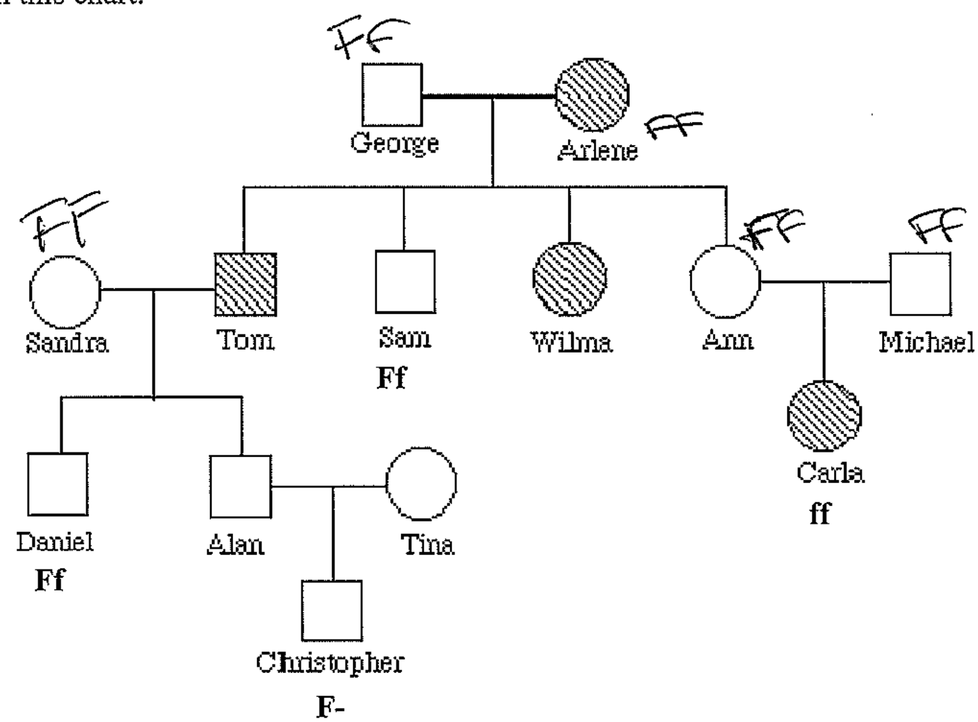
ff 9. What is the most likely genotype of individual "C"? (FF, Ff or ff?)

Example 1: Tracing the path of an autosomal recessive trait

Trait: Fanconi anemia
Forms of the trait:

- The **dominant** form is <u>normal</u> bone marrow function - in other words, no anemia.
- The **recessive** form is Fanconi anemia. Individuals affected show slow growth, heart defects, possible bone marrow failure and a high rate of leukemia.

A **typical pedigree** for a family that carries Fanconi anemia. Note that carriers are **not** indicated with half-colored shapes in this chart.



Analysis Questions.

To answer questions #1-5, use the letter "f" to indicate the recessive Fanconi anemia allele, and the letter "F" for the normal allele.

1. What is Arlene's genotype? ff
2. What is George's genotype? FF
3. What are Ann & Michael's genotypes? FF
4. Most likely, Sandra's genotype is FF.
5. List three people from the chart (other than George) who are most likely *carriers* of Fanconi anemia.

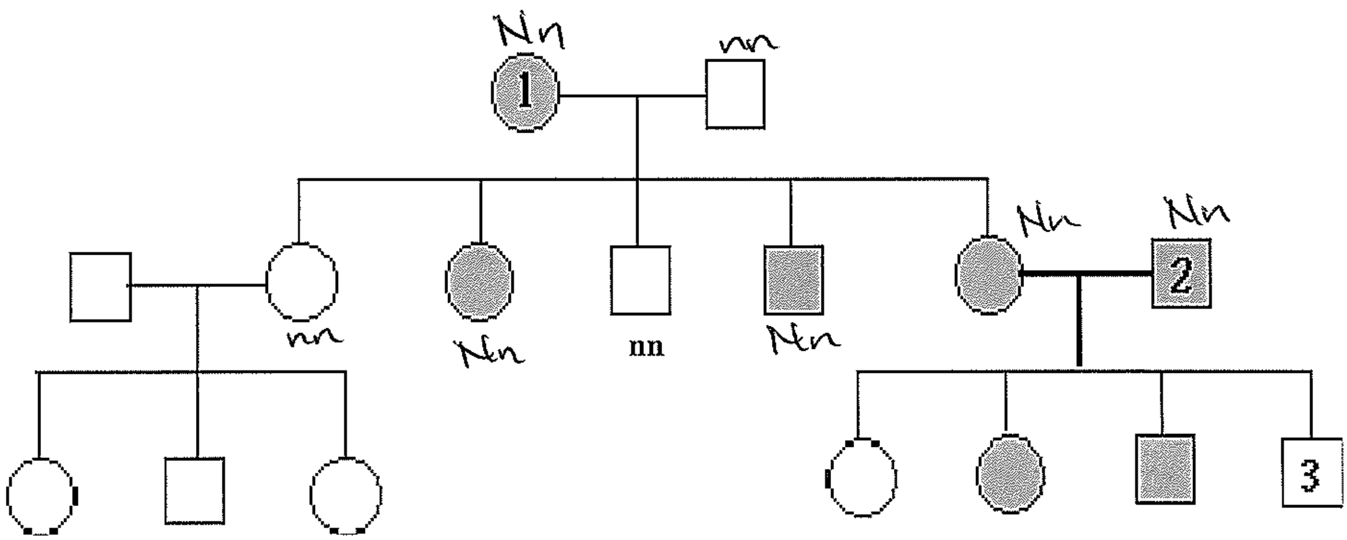
Alan, Sam, Daniel

Example 2: Tracing the path of an autosomal dominant trait

Trait: Neurofibromatosis
Forms of the trait:

- The **dominant** form is neurofibromatosis, caused by the production of an abnormal form of the protein neurofibromin. Affected individuals show spots of abnormal skin pigmentation and non-cancerous tumors that can interfere with the nervous system and cause blindness. Some tumors can convert to a cancerous form.
- The **recessive** form is a <u>normal</u> protein - in other words, no neurofibromatosis.

A **typical pedigree** for a family that carries neurofibromatosis is shown below. Note that carriers are **not** indicated with half-colored shapes in this chart. Use the letter "N" to indicate the dominant neurofibromatosis allele, and the letter "n" for the normal allele.



Analysis Questions:

1. Is individual #1 most likely homozygous dominant or heterozygous? Explain how you can tell.
Heterozygous because she can have unaffected offspring.

2. What is the genotype of individual #3? nn

3. Can you be sure of the genotypes of the affected siblings of individual #3? Explain.
No, it may be NN or Nn.

YOUR TURN!!

Instructions:

1. Draw a pedigree showing all the individuals described in the problem. (Include their names if given.)
2. Label the genotypes of as many individuals in the pedigree as possible.
3. Shade in half of the symbol if you know that the individual is heterozygous or a carrier.

Draw your own Pedigree - Case study #1:

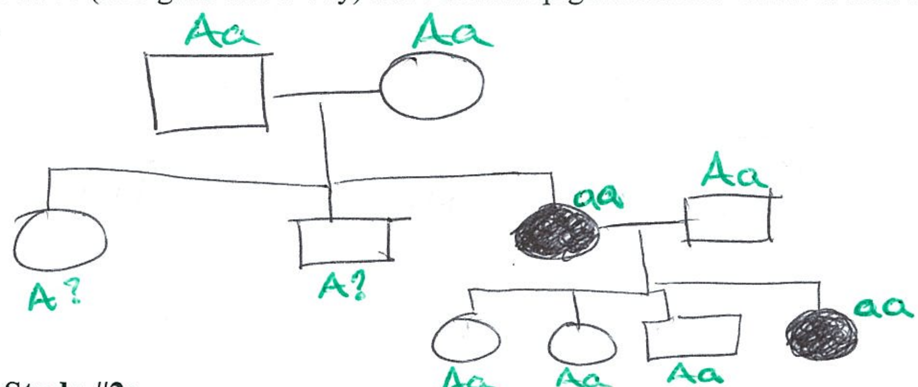
Condition of Interest: Albinism

> *Albinism is a condition in which there is a mutation in one of several possible genes, each of which helps to code for the protein* ***melanin.****. This gene is normally active in cells called melanocytes which are found in the skin and eyes. Albinism involves a significant reduction or absence of the production of melanin, giving affected individuals a lack of normal coloration to their skin/eyes.*

Inheritance Pattern: normal melanin protein is produced by an autosomal dominant allele; albinism results from a lack of melanin and is caused by an autosomal recessive allele.

Use the letter **A** or **a** to represent dominant/recessive forms of albinism.

Two normally-pigmented parents have 3 children. The first child (a girl) and their second child (a boy) have normal pigmentation. Their third child (a girl) has albinism. That girl marries a normally pigmented male and they have four children. The first three (two girls and a boy) have normal pigmentation. Their fourth child (a girl) has albinism like her mother.



Draw your own Pedigree - Case Study #2:

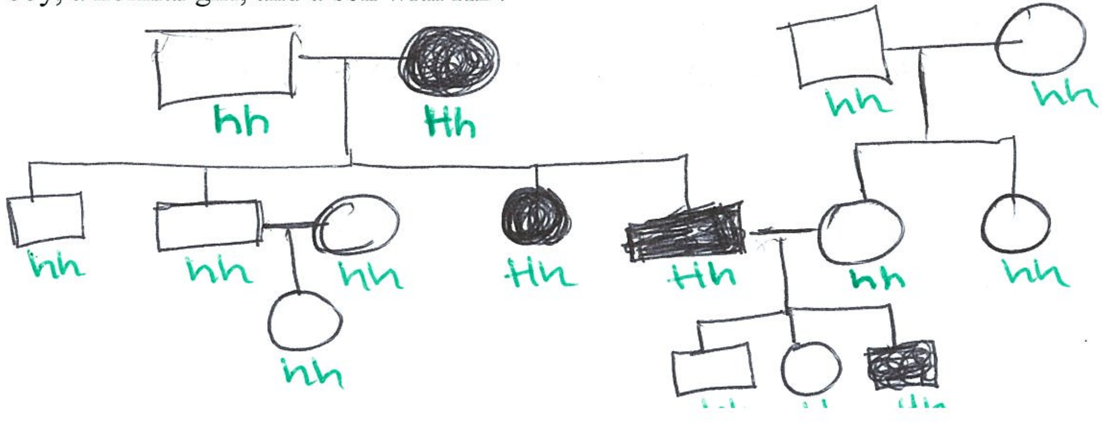
Condition of Interest: Huntington's Disease (also known as HD or Huntington's chorea)

> *Huntington's disease is a neurodegenerative genetic disorder that affects muscle coordination and leads to cognitive decline and dementia.*

Inheritance Pattern: the allele for the normal "Huntington" protein is autosomal recessive; Huntington's disease is caused by an autosomal dominant allele which codes for an abnormal form of the "Huntingtin" protein. Symptoms are more severe in homozygous individuals.

Use **H** or **h** to represent the alleles.

A normal man (Joseph) marries a woman (Rebecca) who is heterozygous for HD and they have four children. Two of their sons (Adam and Charles) are born healthy without HD. Charles marries a woman without HD and they have a normal daughter. Joseph and Rebecca's daughter Tasha and their last son (James) both have HD. James marries a non-HD woman whose sister and parents also do not suffer from HD. James and his wife have three children - a normal boy, a normal girl, and a son with HD.



Draw Your Own Pedigree - Case Study#3:

Trait: blood type

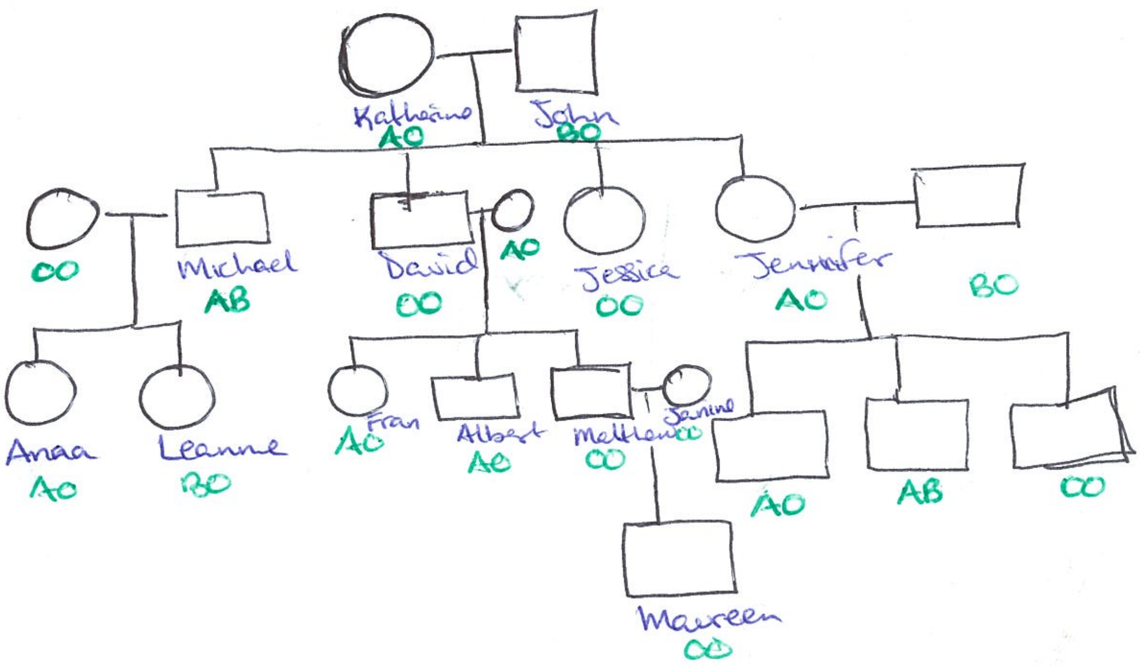
Blood type is determined by the presence of several different proteins found on the surface of red blood cells. Blood type "A" has the A protein; blood type "B" has the B protein; blood type AB has both; blood type O has neither. The +/- indicates another protein called Rh.

Inheritance Pattern: inheritance via autosomal multiple allelism (A, B, or O) results in the blood types A, B, AB or O. The alleles for blood protein A and B are codominant, the "O" allele is recessive to both the A and B alleles.

Use **AA, AO, AB, BB, BO or OO to represent the genotypes.**

As a 9th-grade school project, **Maureen** decides to trace the inheritance of blood types through her extended family, all the way back to her great-grandmother Katherine. Here's what Maureen found out….

Maureen's great-grandmother Katherine, has A type blood. Katherine and her husband John had four children – two sons, Michael (who has blood type AB) and David (who has type O blood); a daughter (Jessica) with type O blood and another daughter (Jennifer) with type A blood. Jessica never married; her sister Jennifer did get married and had three sons (one with type A blood, one with type AB blood and one with type O blood). Both of Katherine's sons also get married – Michael marries a woman with type O blood and together they have two daughters (Anna – type A; Leanne – type B); David marries a woman with type A blood, and they have three children (daughter Fran and son Albert who both have type A blood, and a son Matthew with type O blood). Matthew marries Janine and together they have one daughter, **Maureen**. Maureen knows that her parents both have the same blood type, but she has never yet had a blood test to determine her own blood type.



<u>Draw Your Own Pedigree – Case Study #4</u>

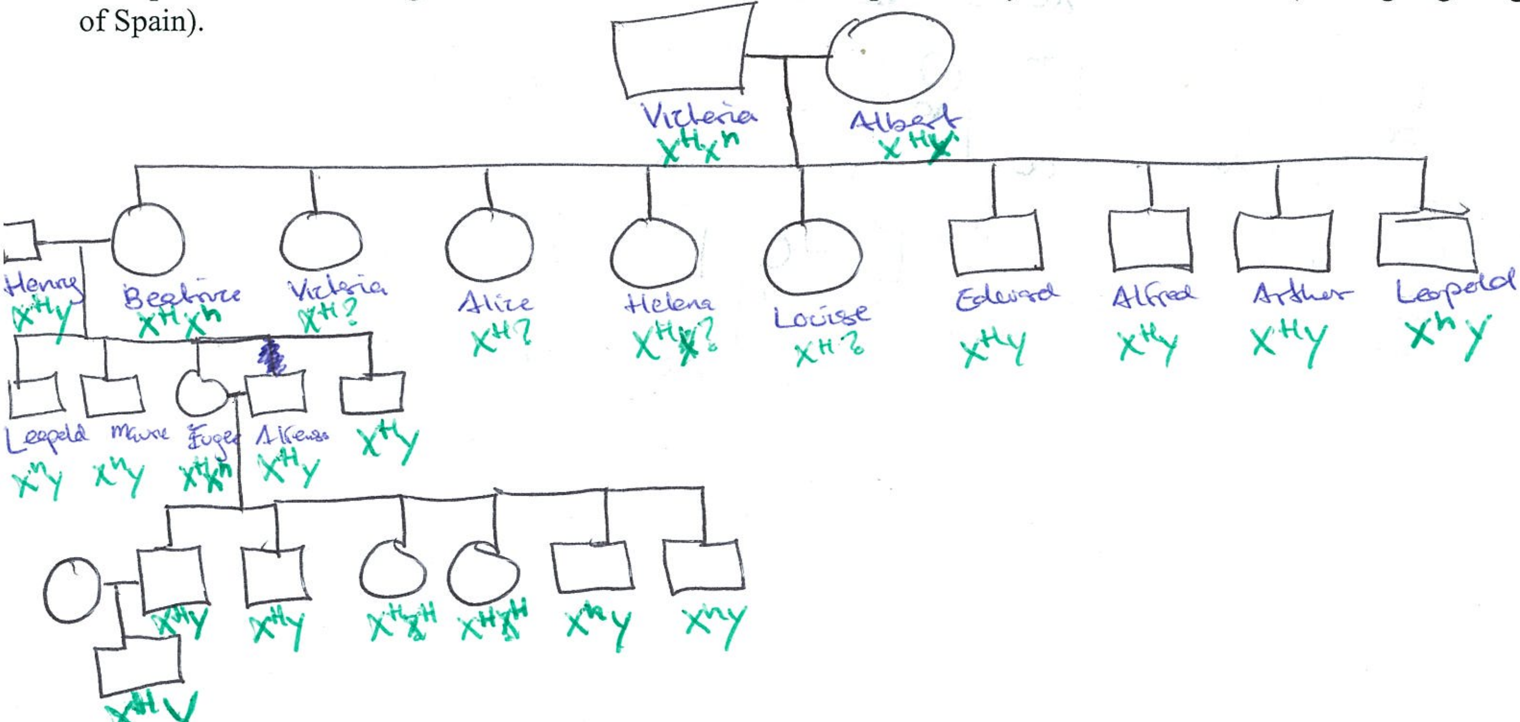
Condition of Interest: Hemophilia

Hemophilia is a blood clotting disorder in which one of the proteins needed to form blood clots is missing or reduced (commonly, the protein known as Factor VIII). Individuals have difficulty forming blood clots following injury and may suffer significant blood loss from even minor cuts and bruises.

Inheritance Pattern: Factor VIII is an essential blood clotting protein which is formed by a normal allele found on the X chromosome; hemophilia is caused by a lack of Factor VIII which results from a recessive allele found on the X chromosome.

Remember that because this is an X-linked disorder, when you identify genotypes in this pedigree, you must use the XX/XY notation and use superscripts with each X chromosome to indicate whether the "H" (normal) or "h" (hemophilia) allele is present. (Ex. X^HY = normal male)

Hemophilia became known as the "Royal disease" after it suddenly cropped up in some of the descendents of Great Britain's Queen Victoria and spread through the royal families of Europe. Queen Victoria and her husband Prince Albert had 9 children – 5 girls (Beatrice, Victoria, Alice, Helena, and Louise – none of whom were hemophiliacs) and 4 boys (Edward, Alfred and Arthur had normal blood clotting; their son Leopold, however was a hemophiliac). Beatrice married a man named Henry and they had four children (sons Leopold and Maurice who were hemophiliacs, daughter Eugenie who was not a hemophiliac, and another son who was also not a hemophiliac). Eugenie married Alfonso XIII of Spain (non-hemophiliac) and they had 6 children (2 normal sons, 2 normal daughters and 2 hemophiliac sons). One of those normal sons married a non-hemophiliac woman and gave birth to one son – a non-hemophiliac they named Juan Carlos (the reigning King of Spain).



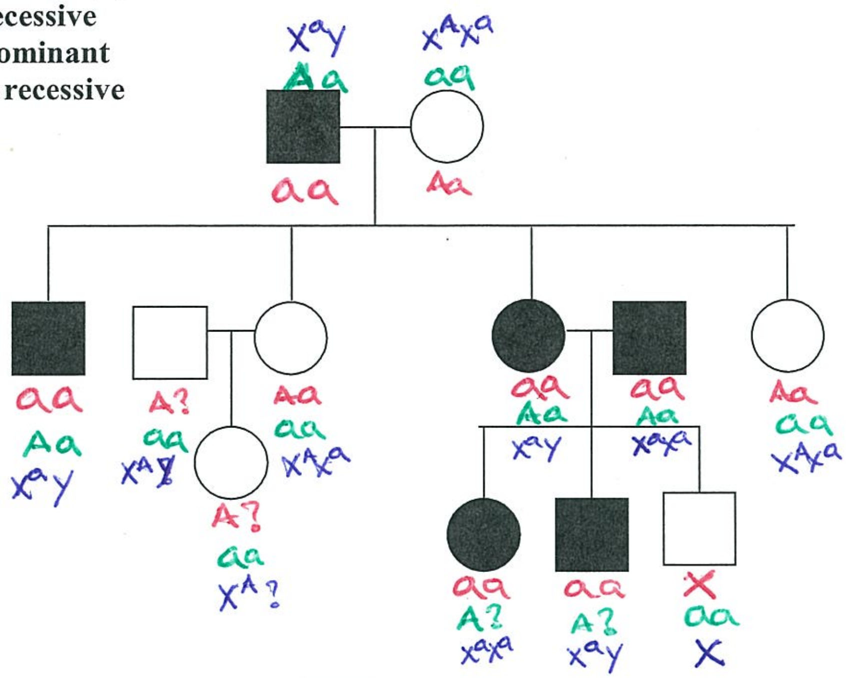
Links for (Optional) Extra Practice:
<u>http://learn.genetics.utah.edu/content/addiction/genetics/pi.html</u>
<u>http://www2.edc.org/weblabs/WebLabDirectory1.html</u> (clink on "Genetic Counselor" for pedigrees)
<u>http://www.zerobio.com/drag_gr11/pedigree/pedigree4.htm</u>
<u>http://www.zerobio.com/drag_gr11/pedigree/pedigree_quiz.htm</u>

CHALLENGE PROBLEMS

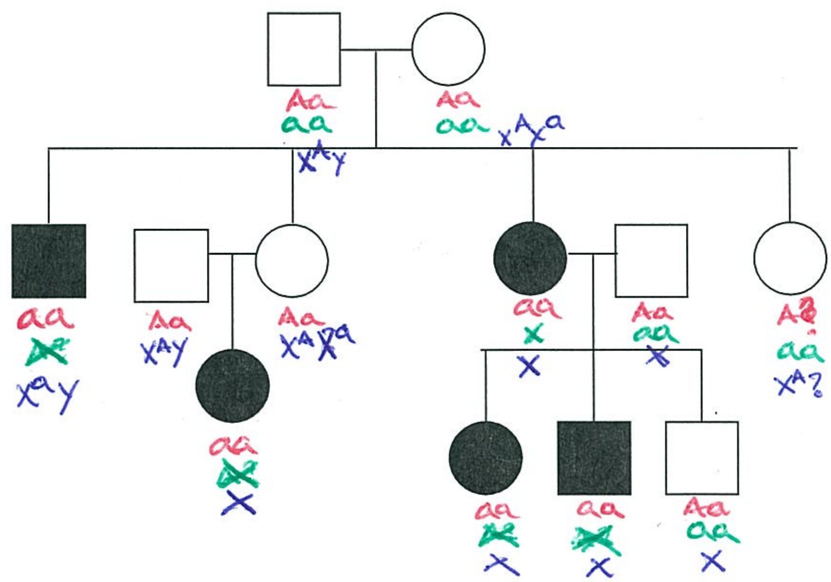
Label the following pedigrees with the letter of the type of trait they display (there is only one of each type so choose carefully!).

a) autosomal recessive
b) autosomal dominant
c) X-sex linked recessive

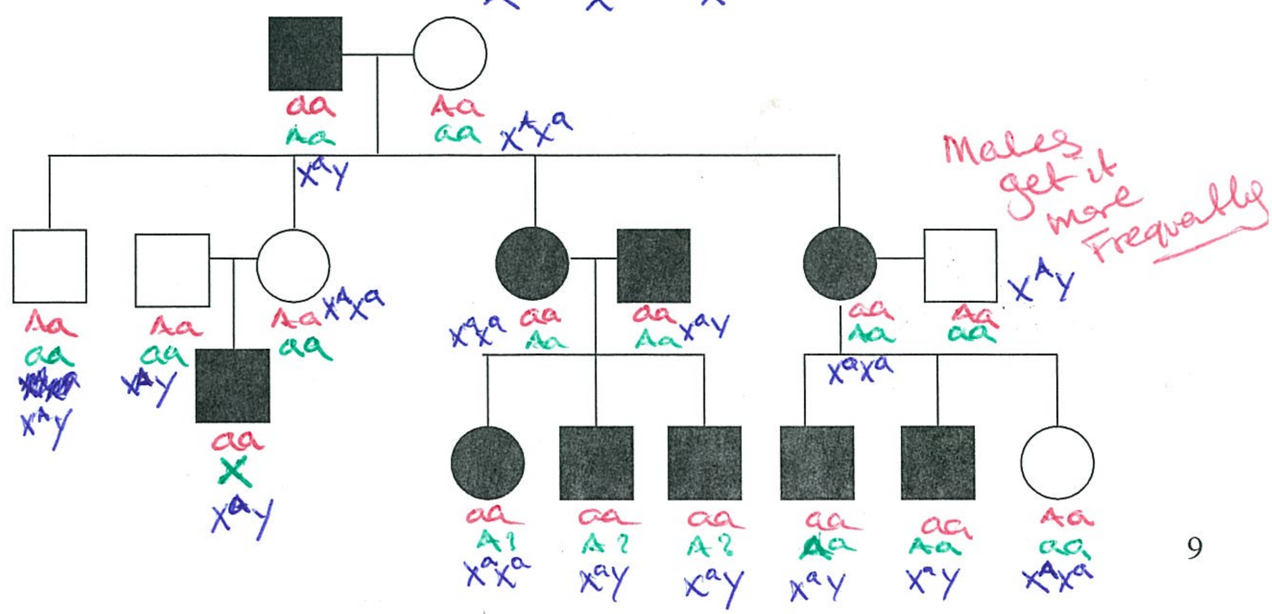
B 1.



A 2.



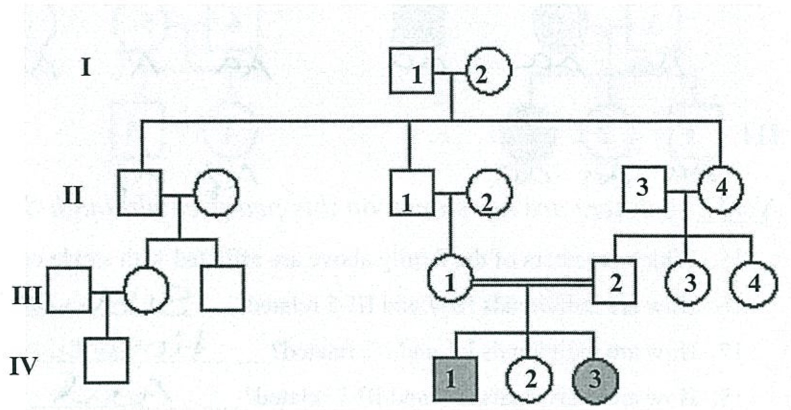
C 3.



Pedigree Worksheet

Use the given pedigrees to answer the following questions:

The pedigree to the right shows the passing on of straight thumbs (recessive) and Hitchhiker's Thumb (dominant) in a family. Shaded shapes mean the person has a straight thumb



1. What is the genotype of IV-1? aa
2. What is the genotype IV-3? aa
3. What is the genotype of III-1? Aa
4. What is the genotype III-2? Aa
5. What is the genotype II-3? AA/Aa
6. Is it possible for individual IV-2 to be a carrier? Yes Why? AaxAa has a 50% chance of being a carrier.

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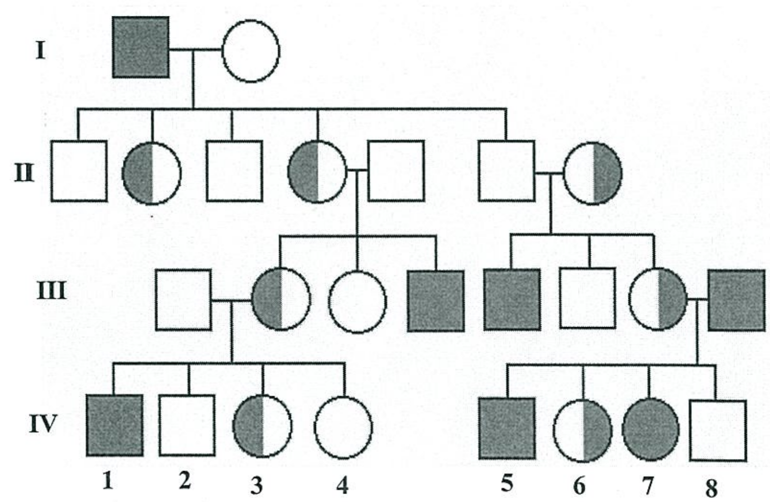
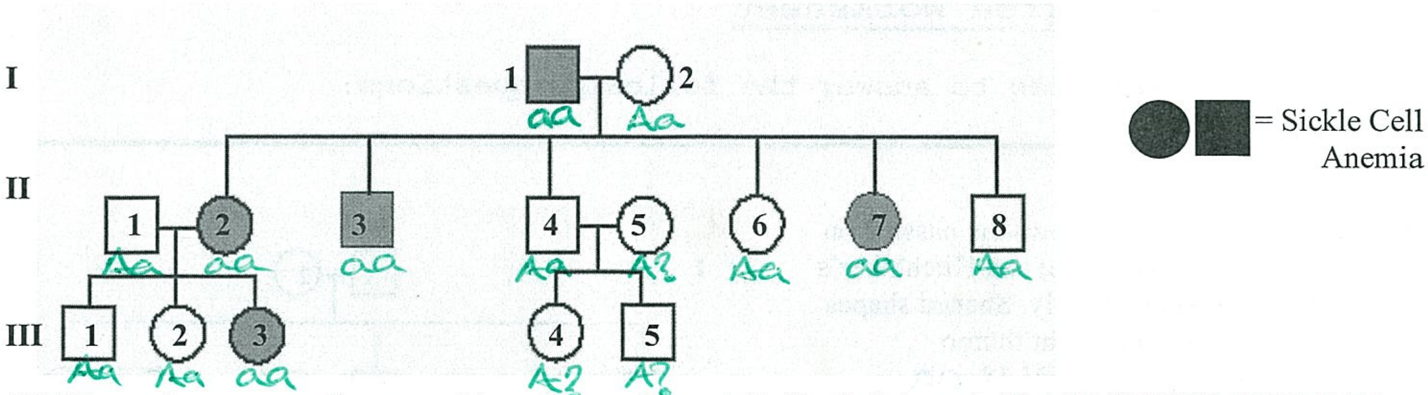
7. The pedigree to the right shows the passing on of colorblindness (a recessive, ***sex-linked trait***). Fill in the numbers for each generation (generation IV is done for you).



8. What do the half shaded circles mean? The women are carriers
9. What is the ONLY sex carriers of colorblindness can be? women
10. Which individuals are colorblind? Males
11. What is the genotype of person II-2? X^CX^c
12. What is the genotype of person I-1? X^cY
13. What is the genotype of person III-3? X^CX^C
14. If person IV-1 marries a female who is not colorblind and is not a carrier, what are the chances of their male offspring being colorblind? 0% What about their female offspring? 0%



NOTE- carriers are not shown on this pedigree although Sickle Cell Anemia IS A RECESSIVE DISORDER.

15. Which members of the family above are afflicted with sickle cell anemia? I 1 II 2 & 3 III 3
16. How are individuals III-4 and III-5 related? Siblings
17. How are individuals I-1 and I-2 related? Husband & wife (parents)
18. How are individuals II-7 and III-2 related? Aunt and Neice
19. How are individuals I-2 and III-5 related? Grandpa ad grandsen
20. How many children did individuals I-1 and I-2 have? 6
21. How many girls did II-1 and II-2 have? 2 How many have sickle cell anemia? 1
22. Label the possible genotypes for all individuals in the pedigree. One person can have more than one possible genotype