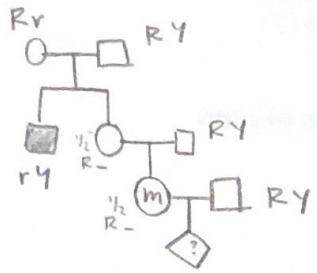
Name Claire Hathaway

√1. **(4 pts)** Mary's mother's brother is red-green colorblind, a sex-linked recessive trait. Everyone else in the family has normal vision. What is the probability that Mary's first child (you do not know if the child is male or female) will be colorblind? **(circle the correct answer)**

0 1/64 1/18 (1/16) 1/9 1/8 1/4 7/16 1/3 1/2 2/3 9/16 3/4 7/8 8/9 15/16 17/18 63/64 1



	R	Y
R	RR	RY
r	Rr	(rY)

1/4

½ x ½ x ¼ = 1/16

√2. **(4 pts)** If you are a male, your **X** chromosome contains genes derived from: **Circle the correct answer**

A) your paternal grandfather only.

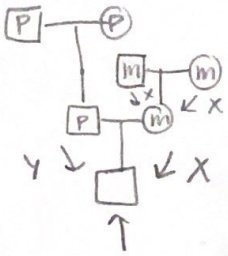
B) both your paternal grandfather and grandmother.

C) both your maternal grandfather and grandmother. –

D) your maternal grandmother only.

E) your maternal grandfather only.

F) both your paternal and maternal grandfathers.



recomb so both

√

3. (4 pts) What is the probability of having a progeny that shows dominant phenotype for all 6 traits from the following cross? Assume all genes map to different chromosomes.

↑ Aa, AA

Answer: 9/64

Aa BB Cc dd Ee Ff X aa bb Cc DD ee Ff

	A	a
a	Aa	aa
a	Aa	aa

½ x

	B	B
b	Bb	Bb
b	Bb	Bb

1 x

	C	c
C	CC	Cc
c	Cc	cc

¾ x

	d	d
D	Dd	Dd
D	Dd	Dd

1 x

	E	e
e	Ee	ee
e	Ee	ee

½ x

	F	f
F	FF	Ff
f	Ff	ff

¾

½ x ¾ x ½ x ¾ = 9/64

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4. (10 pts)
Several different antigens can be detected in blood tests. The following four traits were tested for each individual shown.

ABO type **(I^A and I^B are codominant, i is recessive)**
Rh type **(Rh^+ is dominant to Rh^-)**
MN type **(M and N are codominant)**
Xg^a type **(Xg^{a+} is dominant to Xg^{a-})** X LINKED

All of these blood type genes are autosomal except for Xg^a which is X linked.

A woman recently had a daughter. There are four men who are claiming to be the father. To settle the dispute, the blood types of these individuals were determined. The results are:

Mother	**AB**	**Rh^-**	**MN**	**Xg^{a+}**	+ −
Daughter	**A**	**Rh^+**	**MN**	**Xg^{a-}**	− −
Alleged Father 1	**AB**	**Rh^+**	**M**	**Xg^{a+}**	+ Y
Alleged Father 2	**A**	**Rh^-**	**N**	**Xg^{a-}**	− Y
Alleged Father 3	**B**	**Rh^+**	**N**	**Xg^{a-}**	− Y
Alleged Father 4	**O**	**Rh^-**	**MN**	**Xg^{a-}**	− Y

#3 AB x Bi → Ai
Rh^-Rh^- x Rh^+_ → Rh^+Rh^-
MN x NN → MN
+ − x − Y → − −

A. Which of the alleged fathers could be the real father? **Circle the correct answer(s), there may be more than one.**

Alleged Father 1 Alleged Father 2 (Alleged Father 3) Alleged Father 4

B. Would your answer(s) to part A change if the daughter had the same blood type but also had Turner syndrome (i.e. she was XO)? **Circle the correct answer(s) with the knowledge that the daughter was XO.**

(Alleged Father 1) Alleged Father 2 (Alleged Father 3) Alleged Father 4

− O

If mom + − then dad could be whatever
If mom + + then dad must be − Y

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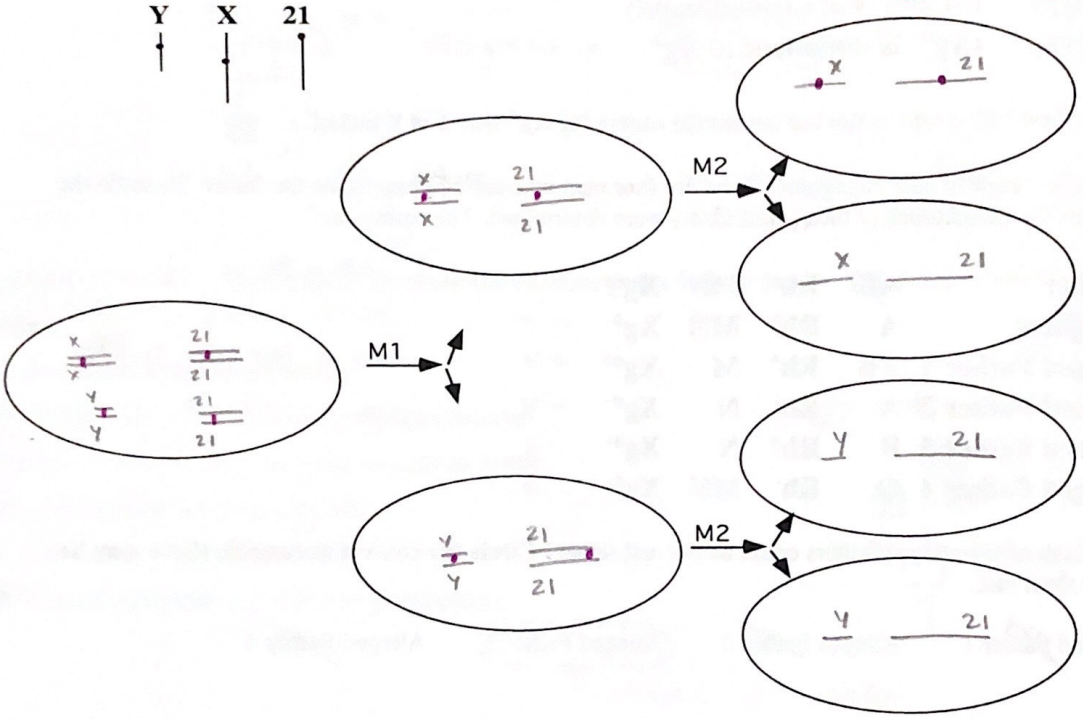
5. (14 pts)
Humans have 23 pairs of chromosomes, the sex chromosomes (X and Y) and 22 pairs of autosomes. Draw the expected arrangement of chromosomes at metaphase of the first meiotic division, metaphase in the 2nd meiotic division, and in the final gamete of a **human male. Draw only the sex chromosomes and chromosome #21 (an autosome).** The structure of a single chromatid of these chromosomes is shown below; notice the relative sizes and the location of the centromere. Be sure to label the chromosomes as either X, Y or 21, and draw in the correct number of chromatids and centromeres.

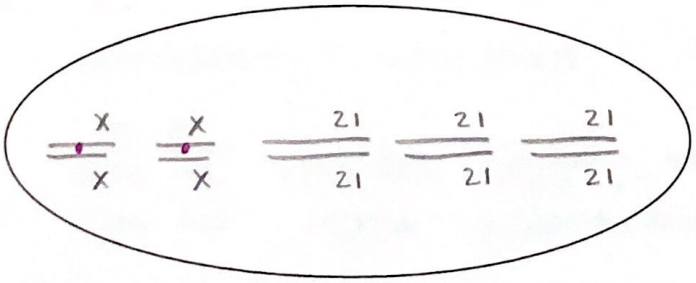
-1



Down syndrome in humans is caused by a nondisjunction event that results in an individual who has three copies of chromosome #21 (females have two copies of all the other chromosomes). Draw the expected arrangement of chromosomes at metaphase of mitosis in a **female with Down syndrome**. Draw only the sex chromosomes and chromosome #21. Be sure to label the chromosomes as either X, Y or 21, and draw the correct number of chromatids and centromeres.

trisomy 21

-1



Name Claire Hamaway

6. (12 pts) causes epistasis?

Three autosomal genes A, B and D are involved in eye color determination. The crosses shown below produce progeny with the following phenotypes and phenotypic ratios:

Compare the results from the three crosses, and based on this comparison determine the genotypes of the progeny. There may be more than one genotype per phenotype.

AaBbDD X AaBbDD -> 9 273 red, 3 91 scarlet, 3 88 brown, 1 29 white → 429 — 4

AaBb × AaBb ↓

9 A_B_DD
3 A_bbDD
3 aaB_DD
1 aabbDD

A_B_DD	A_bbDD	aaB_DD	aabbDD genotypes
AABBDD	AAbbDD	aaBBDD	aabbDD
AABbDD	Aabbdd	aaBbDD	
AaBBDD			
AaBbDD			

epistasis?

AaBBDd X AaBBDd -> 9 180 red, 3 59 brown, 4 82 white → 321 (25% less) — no scarlet (A_bbDD) — 4

9 A_BBD_
white: 3 A_BBdd, 3 aaBBD_, 1 aaBBdd

A_BBD_	aaBBD_	--BBdd genotypes
AABBDD	aaBBDD	AABBdd
AaBBDD	aaBBDd	AaBBdd
AABBDd		aaBBdd
AaBBDd		

AABbDd X AABbDd -> 9 92 red, 3 28 scarlet, 4 40 white → 160 — 4 — no brown (aaB_DD)

9 AAB_D_
white: 3 AAB_dd, 3 AAbbD_, 1 AAbbdd

AAB_D_	AAbbD_	AA__dd genotypes
AABBDD	AAbbDD	AABBdd
AABBDd	AAbbDd	AABbdd
AABbDD		AAbbdd
AABbDd		

Name Claire Hamaway

7. (12 pts)

In the fruit fly *Drosophila* melanogaster, the *white* and the *yellow* genes are on the X chromosome and **are 20 map units apart**. The wild type fly has red eyes and a brown body. The wild type alleles w^+ and y^+ are dominant. In the Parental cross shown below, a *yellow* female (yellow body color) is crossed to a *white* male (white eyes) producing F1 progeny. The F1 progeny are crossed to each other and the F2 progeny counted.

P ♀ $\frac{y \quad w^+}{y \quad w^+}$ X ♂ $\frac{y^+ \quad w}{Y}$ No recombination

A. The phenotype(s) of the F1 male progeny is: [circle correct answer]

(a) Red eyes, brown body

(b) Red eyes, yellow body

(c) white eyes, brown body

(d) white eyes, yellow body

$\frac{y \quad w^+}{Y}$ yellow, red

B. The phenotype(s) of the F1 female progeny is: [circle correct answer]

(a) Red eyes, brown body

(b) Red eyes, yellow body

(c) white eyes, brown body

(d) white eyes, yellow body

$\frac{y \quad w^+}{y^+ \quad w}$ brown, red

20 m.u.

C. In the table below, fill in the expected percentage of phenotypes you would expect among the male and female F2 progeny (these percentages should add up to 100% for each sex).

F2 PHENOTYPE	MALE	FEMALE
Red eyes, brown body	10%	50%
Red eyes, yellow body	40%	50%
white eyes, brown body	40%	
white eyes, yellow body	10%	
TOTAL	100%	100%

$y^+\_$ brown
yy yellow
$w^+\_$ red
ww white

No recom.

♂ $\frac{y \quad w^+}{Y}$ X $\frac{y \quad w^+}{y^+ \quad w}$ ♀

♀ \ ♂	$\frac{y}{y \; w^+}$	$\frac{y}{y^+ \; w}$	$\frac{y}{y \; w}$	$\frac{y}{y^+ \; w^+}$
$\frac{y \; w^+}{y \; w^+}$	YR	BW	YW	BR
$\frac{y \; w^+}{y^+ \; w}$	YR	BW	YW	BR
$\frac{y \; w}{y \; w}$	YR	BW	YW	BR
$\frac{y \; w^+}{y^+ \; w^+}$	YR	BW	YW	BR

0.4 0.4 0.1 0.1

$y w^+$: $1/2 \times 0.8$ } 0.4
$y^+ w$: $1/2 \times 0.8$ }

$y w$: $1/2 \times 0.2$ } 0.1
$y^+ w^+$: $1/2 \times 0.2$ }

0.4 6 0.4 0.1 0.1

$1/2$ YR 0.5
$1/2$ BR 0.5
1

$1/4$ YR 0.4
$1/4$ BW 0.4
$1/4$ YW 0.1
$1/4$ BR 0.1
1

	A	a
A	AA	Aa
a	Aa	aa

1/4

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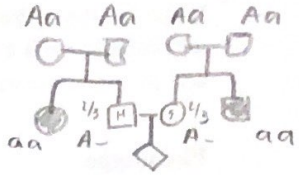
→ 2/3!

8. (8 pts). Neither Harry or Sally have cystic fibrosis, but each have a sibling with this autosomal recessive disorder. Before having children, they discussed the risk that their future offspring would have cystic fibrosis. What is the chance that their first child would have cystic fibrosis?



A) ¼ **B) 2/3** **C) 1/3** **D) 1/9** **E) 1/18**

$2/3 \times 2/3 \times 1/4 = 4/36 = 1/9$

8

If they have an affected child, what is the chance that their next child would be **unaffected**?

A) 2/3 **B) 1/3** **C) 1/4** **D) 3/4** **E) ½**

	A	a
A	AA	Aa
a	Aa	aa

1/4

9. (8 pts) The gene for nose shape is found on the X chromosome. Round nose is dominant to pointed nose. R r

Human individuals with XXY (an additional X chromosome) are male. Individuals with XO (only one X chromosome) are female.

For each of the following families, identify the possible nondisjunction events (**VERY RARE** mistakes during meiosis) that could explain the phenotype of the child. **Circle all that are possible, there may be more than one.**

RY rr RO

A. A man with a round nose and a woman with a pointed nose have a daughter with a round nose. This daughter has Turner Syndrome (genotype XO; one X chromosome).

- (a.) Nondisjunction could have occurred in Meiosis I of the mother
- (b.) Nondisjunction could have occurred in Meiosis II in the mother
- c. Nondisjunction could have occurred in Meiosis I in the father
- d. Nondisjunction could have occurred in Meiosis II in the father.

R from father so he's normal

mom give nothing, could happen in M1 or M2

9

RY Rr

B. A man with a round nose and a woman with a round nose have a son with Klinefelter Syndrome (genotype XXY) with a pointed nose.

rrY

- a. Nondisjunction could have occurred in Meiosis I in the mother
- (b.) Nondisjunction could have occurred in Meiosis II in the mother
- c. Nondisjunction could have occurred in Meiosis I in the father
- d. Nondisjunction could have occurred in Meiosis II in the father.

Y from dad so normal

rr from mom, only happen in M2

Name Claire Hamaway

14

11. (14 pts)

You believe that genes A and B are on different chromosomes and therefore should independently assort. To test this hypothesis you cross a pure bred line that is homozygous for the dominant alleles of A and B with a pure bred line that is homozygous for the recessive alleles a and b. The F1 progeny are test crossed to the recessive line and the F2 progeny counted.

P AABB x aabb

↓

F1 AaBb x aabb

↓

The F2 progeny have the following genotypes:

AaBb	1040
Aabb	990
aaBb	950
aabb	1020
Total	4000

Use the CHI Square test to determine if the data support the hypothesis, that genes A and B are NOT LINKED.

A. If the hypothesis is true, what ratio would you expect among the four classes of progeny?

AaBb Aabb aaBb aabb

1 : 1 : 1 : 1

B. How many degrees of freedom are there in this problem?

Circle one answer: 1 2 (3) 4 5 4-1

C. Determine the CHI Square value [CHI Square = the total sum of $(OBS-EXP)^2/EXP$]

Chi Square value = 4.6

$$\chi^2 = \frac{(1040-1000)^2}{1000} + \frac{(990-1000)^2}{1000} + \frac{(950-1000)^2}{1000} + \frac{(1020-1000)^2}{1000}$$

$$= 1.6 + 0.1 + 2.5 + 0.4 = 4.6$$

D. Do these results support that genes A and B are not genetically linked (that we cannot reject the null hypothesis)?

Circle one answer: (YES) NO

	p Values						
	Cannot Reject the Null Hypothesis				Null Hypothesis Rejected		
Degrees of Freedom	0.99	0.90	0.50	0.10	0.05	0.01	0.001
	χ^2 Values						
1	—	0.02	0.45	2.71	3.84	6.64	10.83
2	0.02	0.21	1.39	4.61	5.99	9.21	13.82
→ 3	0.11	0.58	2.37	6.25	7.81	11.35	16.27
4	0.30	1.06	3.36	7.78	9.49	13.28	18.47
5	0.55	1.61	4.35	9.24	11.07	15.09	20.52

hemophilia only

color-blind only

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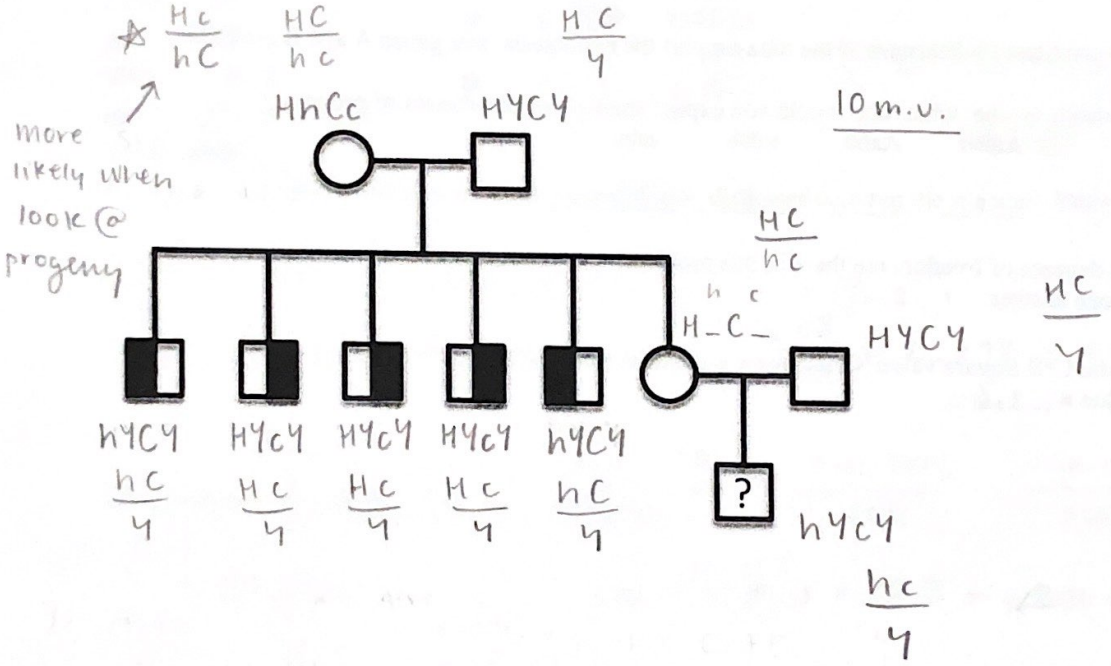
4 point EXTRA CREDIT PROBLEM
THIS IS A CHALLENGING PROBLEM, WORK ON IT ONLY IF YOU HAVE FINISHED THE REST OF THE EXAM. No Partial Credit.

Shown below is a pedigree of a family affected with the X-linked recessive traits hemophilia and Red-Green colorblindness. The hemophilia and Red-Green colorblind genes map 10 m.u. apart. The males in the 2nd generation shaded on the left side have hemophilia (and not Red-Green colorblindness) and the males shaded on the right side have Red-Green colorblindness but not hemophilia. The rest of the family has neither trait. Determine the probability the boy in the 3rd generation noted with the **?** will have both hemophilia and colorblindness.

Probability boy has both hemophilia and Red-Green Colorblindness = X 2.5%



Hc / hC give → ½ × 0.1 = 0.05 } 0.025 → 2.5%.