

Today's class:

Finish patterns of autosomal inheritance.

Calculating probabilities that two parents will produce offspring with specific genotypes/phenotypes for autosomal (today) and X-linked traits (maybe Tuesday) – for one and two traits.

Using offspring phenotypes to infer parental genotypes (autosomal)

Using a test cross to infer parental genotypes (autosomal)

Patterns: X-linked Dominant and Recessive Mode of Inheritance (Start)

Patterns: When alleles have a non-dominant relationship (Tuesday)

A bit of housekeeping

Academic concession module now on Canvas homepage (at the bottom).

- if you have discussed academic concessions with me (e.g. missed quizzes, etc.), please fill out the form in this module, and submit to Canvas using the submission link.
- no submission limits; but, if you ask for a future concession, you will need to make sure any form you upload is complete.

Midterm #1 module now open.

Group Project module now open, but incomplete.

Note – when submitting worksheets/assignments to Canvas, please do NOT use HEIC format. We can't open this file format; so, you may receive a zero. Please submit .docx, pdf or jpeg files. Thanks!

Final study tip – study efficiently

- Try to avoid studying for long, continuous stretches of time
 - = diminishing returns
 - human brain can only focus for about 20 minutes
- When studying, perhaps try using the Pomodoro Method
(<https://learningcommons.ubc.ca/the-pomodoro-technique-study-more-efficiently-take-more-breaks/>)
 - Study for 25 minutes
 - Take a 5 minute break
 - = 25 min. study time + 5 min. break = one pomodoro
 - Repeat
 - After 4 Pomodoro's take a 30 minute break.
 - Repeat

Last class – Autosomal mode of inheritance (gene is on an autosome)

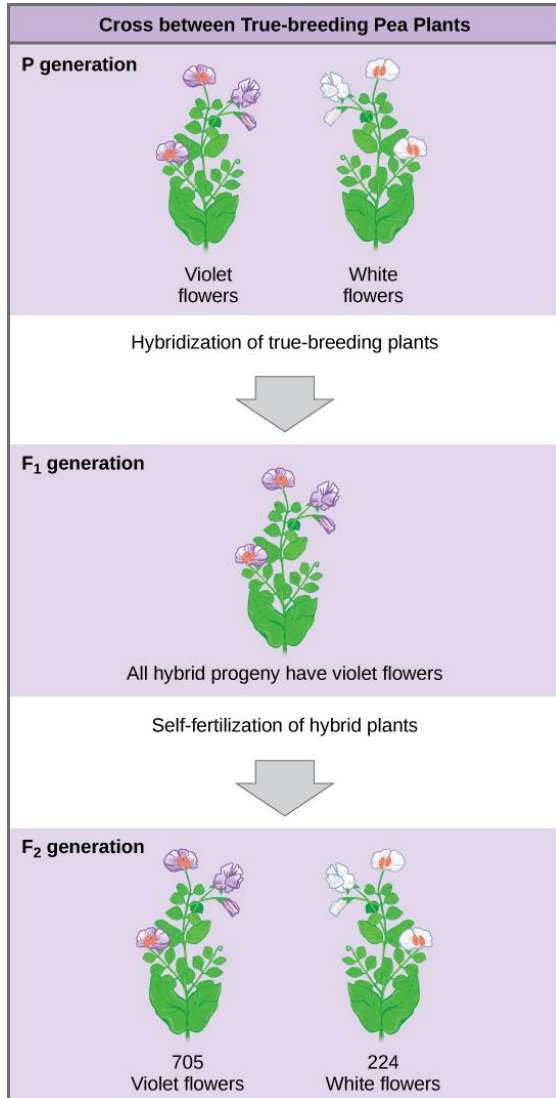
Autosomal Dominant – individuals need just one dominant allele to have dominant phenotype (BB or B₋)



Autosomal Recessive – individuals must carry two recessive alleles (bb) to have the recessive phenotype



Patterns – autosomal inheritance



Keying patterns (autosomal inheritance, non-linked genes, dominant/recessive alleles):

- **Parents:** If you cross two true-breeding/pure-breeding parents (with different phenotypes), all of the F1 offspring will have the same dominant phenotype. (note – this pattern can occur if gene X-linked too)
- **F1s:** All (F1 male and females) will be hybrids/heterozygotes; therefore, the F1 generation will tell you the relationship between the alleles (e.g. purple flowers dominant to white flowers).
- **F2s:** If you cross two hybrids/heterozygotes (i.e. do a monohybrid cross), then you should see a **3:1 phenotype ratio** (approximately) in the F2 generation.
- There will be no difference in phenotype between males and females in BOTH the F1 and F2 generation (contrast with X-linked patterns).

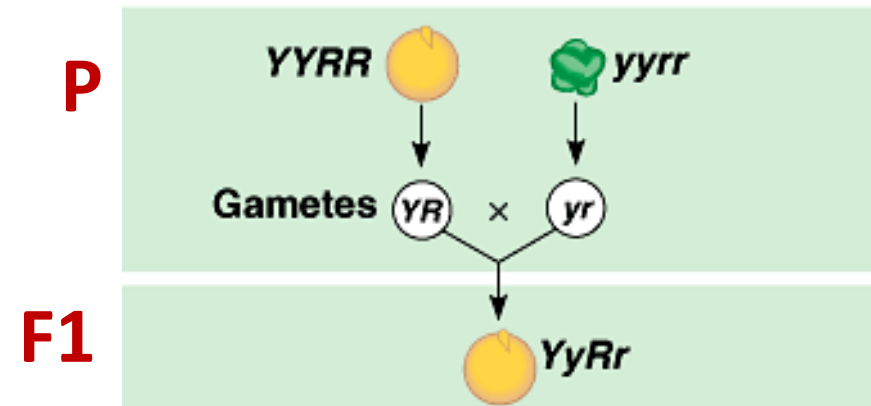
Mendel: Two traits

Mendel wanted to test what happened when he crossed peas that were heterozygous for **two traits***.

Traits of choice:

- Seed colour
 - Yellow (Y) is dominant to green (y)
- Seed shape
 - Round (R) is dominant to wrinkled (r)

Step 1: Mendel created a **dihybrid** F1 generation by crossing true-breeding parents:



All the F1 offspring have yellow, round seeds

* These genes are **unlinked** (on separate chromosomes).

Mendel then crossed his F1s
(YyRr x YyRr), i.e. did a dihybrid cross*, to produce an F2 generation

Mendel observed the following phenotypes in his crosses:

Parents: round seeds, yellow seeds X wrinkled seeds, green seeds

F1: all round and yellow seeds

		<u>Number</u>	<u>Fraction</u>
F2:	round, yellow	315	9/16
	round, green	108	3/16
	wrinkled, yellow	101	3/16
	wrinkled, green	32	1/16

Note: not exactly 3:1 phenotype ratio

- round:wrinkled = 413:133 or 3.1:1
- yellow: green = 416:140 or 2.9:1

So, Mendel observed a 9:3:3:1 phenotypic ratio (when considering both traits together).

Or, a 3:1 phenotypic ratio if you separate each trait.

Yellow:green = 416: 140 or ~ 3:1

Round:wrinkled = 415:133 or ~ 3:1

***A dihybrid cross describes a mating experiment between two organisms that are identically hybrid for two traits**

Mendel's dihybrid cross

Mendel allowed the F1 to self-pollinate
(YyRr x YyRr)?

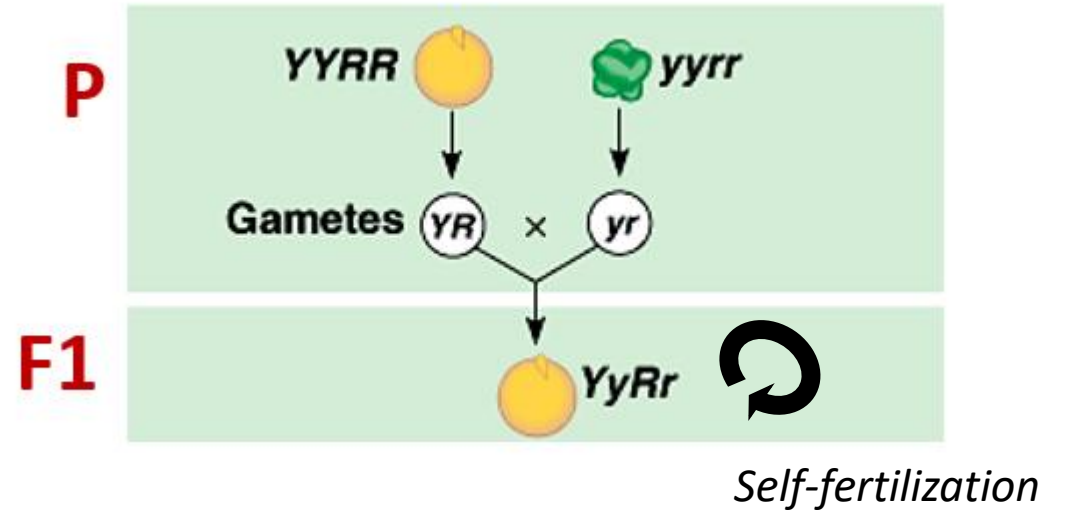
Each hybrid parent could produce 4
gamete genotypes

YR

Yr

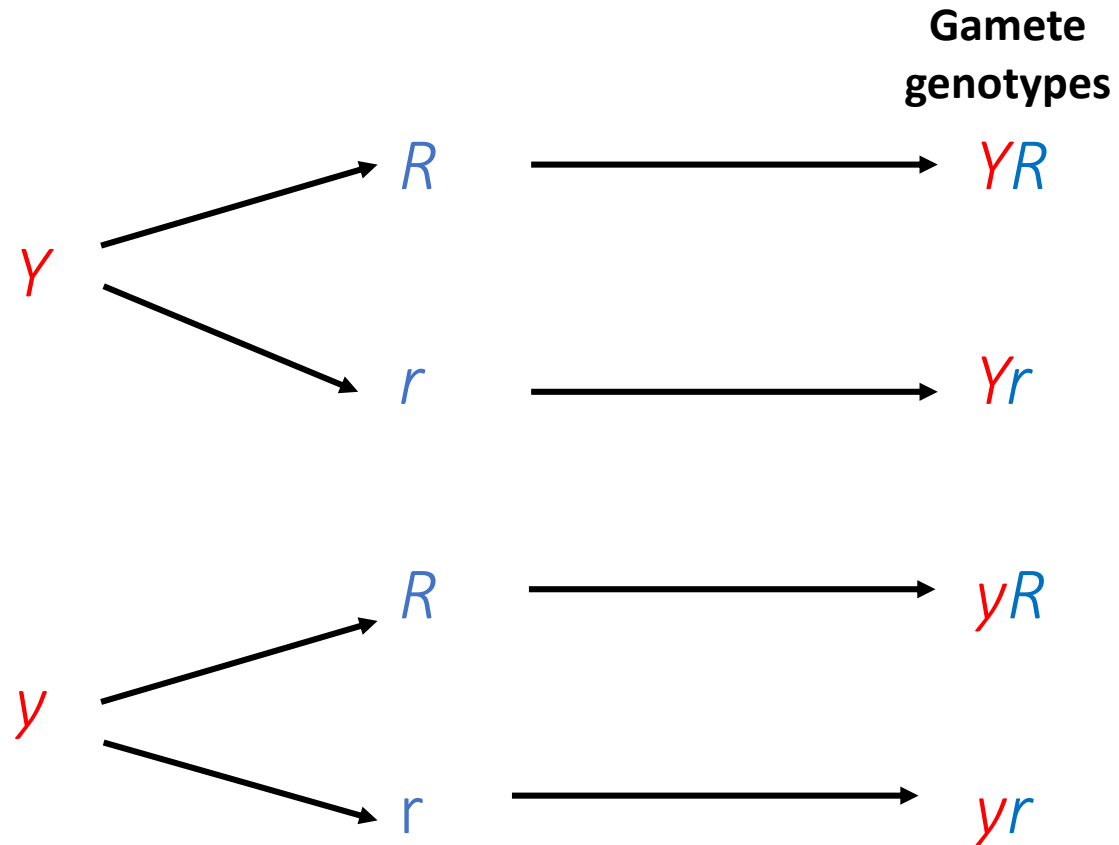
.yR

.yr

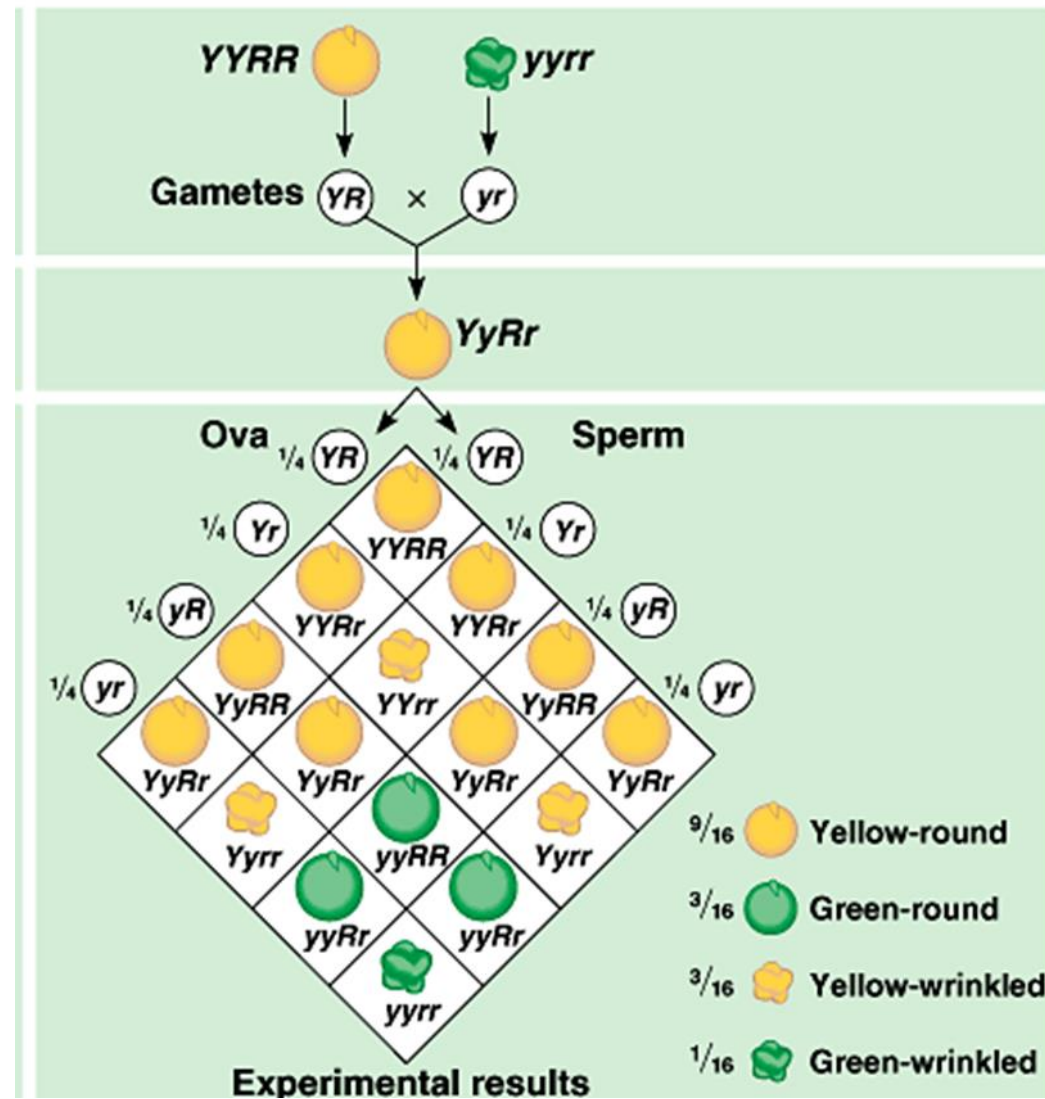


Answer – for each parent

$YyRr \times YyRr$



Predicted genotypes and phenotypes - two traits (autosomal genes, not linked) – a large Punnett Square (not recommended).



Note: 3:1 ratio for each trait (seed colour and seed shape)

Round = 12, Wrinkled = 4

Yellow = 12, Green = 4

Predicted genotype/phenotype frequencies - alternative (recommended),
create a Punnett Square for each trait (if genes not linked)

Mendel's Two Trait Experiment – F1 cross (YyRr x YyRr)

Seed Colour – Yy x Yy

	Y	.y
Y	YY	Yy
.y	Yy	.yy

Yellow seeds (Y₋): 3 out of 4
Green seeds (yy): 1 out of 4

Y = yellow
.y = green
R = round
.r = wrinkled

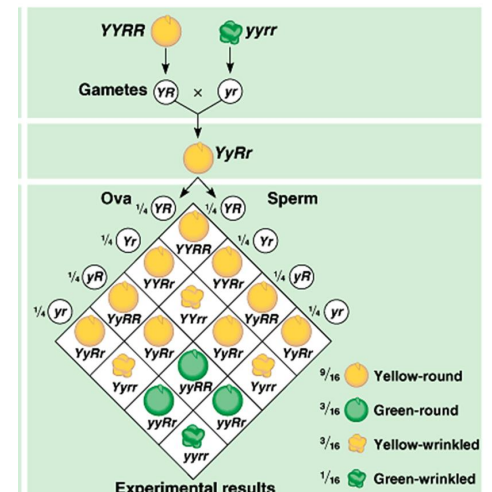
Seed Shape – Rr x Rr

	R	.r
R	RR	Rr
.r	Rr	.rr

Round seeds (R₋): 3 out of 4
Wrinkled seeds (rr): 1 out of 4

So:

predicted frequency of yellow round seeds (Y₋R₋) = $\frac{3}{4} \times \frac{3}{4} = \frac{9}{16}$
predicted frequency of green, round seeds (yyR₋) = $\frac{3}{4} \times \frac{1}{4} = \frac{3}{16}$
predicted frequency of yellow, wrinkled seeds (Y₋rr) = $\frac{3}{4} \times \frac{1}{4} = \frac{3}{16}$
predicted frequency of wrinkled green seeds (yyrr) = $\frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$



Summary - autosomal inheritance (to this point)

Offspring Phenotypic Ratio	Gene	Relationship btwn Alleles	Parents	Notes
Only one phenotype	One gene	Dominant/recessive	Parents are true-breeding (autosomal)	May also see this pattern if gene is X-linked and female parent carries dominant allele.
3:1	One gene	Dominant/recessive	2 heterozygotes	
9:3:3:1	Two genes, unlinked	Dominant/recessive	2 heterozygotes	

iClicker Question

Based on the tomato cross described in the table below, which phenotypes are dominant? Assume the genes are on different chromosomes, and can assort independently.

Male parents	Female parents	Offspring (F1)
Red, round	Yellow, oblong	100% Red, oblong

- A. Red and round are dominant to yellow and oblong
- B. Yellow and round are dominant to red and oblong
- C. Red and oblong are dominant to yellow and round
- D. Yellow and oblong are dominant to red and round
- E. Help!



X



Answer

Based on the tomato cross described in the table below, which phenotypes are dominant?

Male parents	Female parents	Offspring (F1)
Red, round	Yellow, oblong	100% Red, oblong

- A. Red and round are dominant to yellow and oblong
- B. Yellow and round are dominant to red and oblong
- C. Red and oblong are dominant to yellow and round
- D. Yellow and oblong are dominant to red and round
- E. Help!



X



iClicker Question

Are the parents likely true breeding?

Male parent	Female parent	Offspring (F1)
Red, round	Yellow, oblong	100% Red, oblong

- A. Yes
- B. No
- C. Need more information
- D. Not sure
- E. Fan of the letter E



X



Answer

Are the parents likely true breeding?

Male parent	Female parent	Offspring (F1)
Red, round	Yellow, oblong	100% Red, oblong

A. Yes

B. No

C. Need more information

D. Not sure

E. Fan of the letter E

If the male parent was a heterozygote for colour (e.g. Rr) and the female parent had the genotype (rr), what offspring phenotypes would you expect?

	r	
R	Rr	Red
.r	.rr	Yellow



X



Question – F2 phenotype frequencies

If the F1 tomatoes (RrGg) were allowed to self-pollinate, and the genes were not linked (i.e. they were on different chromosomes) with a dominant/recessive relationship, what would be the predicted phenotype frequencies for the F2 tomatoes?

- A. 3:1 red to yellow and 3:1 oblong to round
- B. 9:3:3:1 red/oblong to red/round to yellow/oblong/ to yellow/round
- C. 1:1 red round to yellow oblong
- D. 1:1:1:1 red/oblong to red/round to yellow/oblong/ to yellow/round
- E. A & B



X



Answer

If the F1 tomatoes (RrGg) were allowed to self-pollinate, and the genes were not linked with a dominant/recessive relationship, what would be the predicted phenotype frequencies for the F2 tomatoes?

- A. 3:1 red to yellow and 3:1 oblong to round
- B. 9:3:3:1 red/oblong to red/round to yellow/oblong/ to yellow/round
- C. 1:1 red round to yellow oblong
- D. 1:1:1:1 red/oblong to red/round to yellow/oblong/ to yellow/round
- E. A & B



X



iClicker question – linked genes

If the parent tomatoes were true-breeding ($RRgg \times rrGG$) and the genes were linked (with no crossing-over), what would be the predicted phenotype frequencies for the F1 tomatoes?

P: Red, round \times yellow, oblong. R=red, r=yellow, G=oblong, g=round

- A. 3:1 red/oblong to yellow/round
- B. 9:3:3:1 red/oblong to red/round to yellow/oblong/ to yellow/round
- C. 1:1 red/round to yellow/oblong
- D. 1:1:1:1 red/oblong to red/round to yellow/oblong/ to yellow/round
- E. All red/oblong



X



Answer

If the parent tomatoes were true-breeding ($RRgg \times rrGG$) and the genes were linked (with no crossing-over), what would be the predicted phenotype frequencies for the F1 tomatoes?

P: Red, round \times yellow, oblong. R =red, r =yellow, G =oblong, g =round

- A. 3:1 red/oblong to yellow/round
- B. 9:3:3:1 red/oblong to red/round to yellow/oblong/ to yellow/round
- C. 1:1 red/round to yellow/oblong
- D. 1:1:1:1 red/oblong to red/round to yellow/oblong/ to yellow/round
- E. All red/oblong

	rG
Rg	RrGg

If genes are linked you cannot create separate Punnett Squares for each trait.



X



Learning goal

- Know the meaning of the term test-cross.

In a test cross, an individual(s) with a known or unknown genotype is crossed with an individual(s) that is homozygous recessive (tester) for the genes under consideration

iClicker Question

If you crossed the F1 generation tomatoes (RrGg) with a test cross (rrgg) and the genes were not linked, what phenotype would you expect in the F2 generation and in what frequencies? R=red, r=yellow, G=oblong, g=round

- A. Red and round, red and oblong
- B. Yellow and round, yellow and oblong
- C. Equal frequencies
- D. More parental than recombinants
- E. A, B and C

Answer

If you crossed the F1 generation tomatoes (RrGg) with a test cross (rrgg) and the genes were not linked, what phenotype would you expect in the F2 generation and in what frequencies? R=red, r=yellow, G=oblong, g=round

- A. Red and round, red and oblong
- B. Yellow and round, yellow and oblong
- C. Equal frequencies
- D. More parental than recombinants
- E. A, B and C

	rg	
RG	RrGg	Red, oblong
Rg	Rrgg	Red, round
rG	rrGg	Yellow, oblong
rg	rrgg	Yellow, round

iClicker Question

If you crossed the F1 generation tomatoes (RrGg) with a test cross (rrgg) and the genes were linked (with no crossing-over), what phenotypes would you expect in the F2 generation? R=red, r=yellow, G=oblong, g=round

- A. Red and round
- B. Yellow and oblong
- C. Red and oblong
- D. Yellow and round
- E. A and B

Answer

If you crossed the F1 generation tomato with a test cross and the genes were linked (with no crossing-over), what phenotype would you expect in the F2 generation? R=red, r=yellow, G=oblong, g=round

	rg	F2 phenotype
Rg	Rrgg	Red, round
rG	rrGg	Yellow, oblong

In this test cross, the F2 offspring have the same phenotype as which generation? P generation of F1 generation?

- A. Red and round
- B. Yellow and oblong
- C. Red and oblong
- D. Yellow and round
- E. A and B

Male parents	Female parents	Offspring (F1)
Red, round	Yellow, oblong	100% Red, oblong

To know which alleles are linked, you need to look at the P-generation.

Male in P generation: red and round (R, g). So these 2 alleles must be on the same chromosome, which was inherited as one of two homologs by the F1 generation
Female in P generation: yellow and oblong (r, G). So, these two alleles must be on the same chromosome, which was also inherited by the F1 generation

iClicker Question

If you crossed the F1 generation tomatoes (RrGg) with a test cross (rrgg) and the genes were linked (and crossing-over could occur), what phenotype would you expect in the F2 generation? R=red, r=yellow, G=oblong, g=round

- A. Red and round
- B. Yellow and oblong
- C. Red and oblong
- D. Yellow and round
- E. All of the above

Answer

If you crossed the F1 generation tomatoes (RrGg) with a test cross (rrgg) and the genes were linked (and crossing-over could occur), what phenotypes would you expect in the F2 generation? R=red, r=yellow, G=oblong, g=round

- A. Red and round
- B. Yellow and oblong
- C. Red and oblong
- D. Yellow and round
- E. All of the above

	.rg	Phenotype
RG	RrGg	Red, oblong
Rg	Rrgg	Red, round
.rG	.rrGg	Yellow, oblong
.rg	.rrgg	Yellow, round

iClicker Question

Assuming thousands of offspring were produced from a mating between a heterozygous F1 and a tester, and crossing-over could occur, what phenotype frequencies would you expect?

- A. All 4 phenotypes, equal frequencies
- B. Red/round & Yellow/oblong >> Red/oblong & Yellow/round
- C. Red/round & Yellow/oblong << Red oblong & Yellow/round
- D. I am not sure

Answer

Assuming thousands of offspring were produced from a mating between a heterozygous F1 and a tester, and crossing-over could occur, what phenotype frequencies would you expect?

- A. All 4 phenotypes, equal frequencies
- B. Red/round & Yellow/oblong >> Red/oblong & Yellow/round
- C. Red/round & Yellow/oblong << Red oblong & Yellow/round
- D. I am not sure

Red/round & Yellow/oblong = parental (P generation, not F1)

Red/oblong & Yellow/round = recombinant phenotype

Summary - autosomal inheritance (to this point)

Offspring Phenotypic Ratio	Gene	Relationship btwn Alleles	Parents	Notes
Only one phenotype	One gene	Dominant/recessive	Parents are true-breeding (autosomal)	Outcome of Mendel's P generation crosses with peas May also see this pattern if gene is X-linked and female parent carries dominant allele.
Two phenotypes 3:1	One gene	Dominant/recessive	2 heterozygotes	Outcome of Mendel's F1 monohybrid crosses (heterozygotes) (peas)
Four phenotypes 9:3:3:1	Two genes, unlinked	Dominant/recessive	2 heterozygotes	Outcome of Mendel's F1 dihybrid crosses (heterozygotes) (peas)
Four phenotypes 1:1:1:1	Two genes, unlinked	Dominant/recessive	Heterozygote x test cross	Tomato example, this lecture Also tomato worksheet #4
Two phenotypes 1:1 – offspring have the original P generation phenotypes	Two genes, linked with no crossing-over	Dominant/recessive	Heterozygote x test cross	Tomato example this lecture Also tomato worksheet #4
4 phenotypes, greater freq. of non-recombinant (P gen.) than recombinant phenotypes	Two genes, linked, crossing-over	Dominant/recessive	Heterozygote x test cross	Tomato example, this lecture. Also tomato worksheet #4

4-minute break





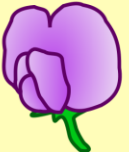



Learning objective

Be able to calculate the probability that two parents will produce offspring with specific traits

How to calculate probabilities from Punnett squares?

What is the probability that a Bb X Bb cross will produce an offspring that has purple flowers?



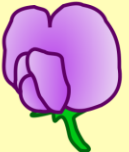

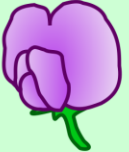

- A. 100%
- B. 75%
- C. 50%
- D. 25%
- E. Help 😞

		 pollen ♂	
		B	b
 pistil ♀	B	 BB	 Bb
	b	 Bb	 bb

Answer

What is the probability that a Bb X Bb cross will produce an offspring that has purple flowers?



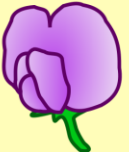

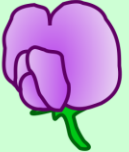

- A. 100%
- B. 75%**
- C. 50%
- D. 25%
- E. Help 😞

		 pollen ♂	
		B	b
 pistil ♀	B	 BB	 Bb
	b	 Bb	 bb

iClicker Question

What is the probability that a Bb X Bb cross will produce offspring with genotype Bb?



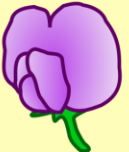

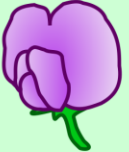

- A. 100%
- B. 75%
- C. 50%
- D. 25%
- E. Help 😞

		 pollen ♂	
		B	b
 pistil ♀	B	 BB	 Bb
	b	 Bb	 bb

Answer

What is the probability that a Bb X Bb cross will produce offspring with genotype Bb?

- A. 100%
- B. 75%
- C. 50%
- D. 25%
- E. Help 😞

		 pollen ♂	
		B	b
 pistil ♀	B	 BB	 Bb
	b	 Bb	 bb

Question – probabilities – one trait

You cross a heterozygous black-furred dire wolf with white-furred dire wolf. Black fur (F) is dominant to white fur (f). They have one offspring.

What is the probability that dire wolf pup will have black fur?

- A. 0%
- B. 25%
- C. 50%
- D. 75%
- E. 100%



Answer

You cross a heterozygous black-furred dire wolf with white-furred dire wolf. Black fur (F) is dominant to white fur (f). They have one offspring.

What is the probability that dire wolf pup will have black fur?

- A. 0%
- B. 25%
- C. 50%
- D. 75%
- E. 100%

	.f	.f
F	Ff	Ff
.f	.ff	.ff



Question – probabilities – one trait

If two heterozygous dire wolves (Ff) have mated for life and produced many offspring. The first five offspring were all black. What is the probability the next cub will be white?

- A. $1/6$
- B. $1/4$
- C. $1/2$
- D. $3/4$
- E. Not enough information to know



Question – probability – one trait

If two heterozygous dire wolves (Ff) have mated for life and produced many offspring. The first five offspring were all black. What is the probability the next cub will be white?

A. $1/6$

B. $1/4$

C. $1/2$

D. $3/4$

E. Not enough information to know

The outcome of this cross is independent of the outcome of previous crosses!

	F	f
F	FF	Ff
f	Ff	ff



Calculate the probability of producing an offspring with **two or more phenotypes**

- With two traits in the mix, we need to apply **probability rules**:

“And”
(e.g. white fur and female)
MULTIPLY probabilities

“Or”
(e.g. black fur or white fur)
ADD probabilities

Question – probability – two traits (“And”)

What is the probability that a female black bear who was **heterozygous** for the *mc1r* gene (F/f) would have a **white female** cub if she mated with a **heterozygous** male black bear?

Allele for black fur (F) is dominant to the allele for white fur (f).

- A. 12.5%
- B. 25%
- C. 37.5%
- D. 50%
- E. Not sure



Answer

What is the probability that a female black bear who was **heterozygous** for the *mc1r* gene (F/f) would have a **white female** cub if she mated with a **heterozygous** male black bear?

- A. 12.5%
- B. 25%
- C. 37.5%
- D. 50%
- E. Not sure



Explanation: What is the probability that a female black bear who was **heterozygous** for the *mc1r* gene (F/f) would have a **white female** cub if she mated with a **heterozygous** male black bear?

Cub with
white fur:



	F	f
F	FF	Ff
f	Ff	ff

$\frac{1}{4}$ or 25 %

Female cub:



	X	Y
X	XX	XY
X	XX	XY

$\frac{1}{2}$ or 50 %

$$\frac{1}{4} \times \frac{1}{2} = \frac{1}{8} = 12.5\%$$

iClicker Question - probabilities – 2 traits

Relevant background information?

What the question is prompting you to do?

In the fictional insect *Cutis bugum*, eye colour and antenna length are each controlled by a **single autosomal gene** with two alleles:

- Red eyes (E) are **dominant** to green eyes (e)
- Short antennae (A) are **dominant** to long antennae (a)

You know these organisms are **diploid*** and the **genes in question are unlinked**.

You perform a cross, creating individuals with the genotype **EeAa**. If **these individuals mate with one another**, **what is the probability they will have a female offspring with green eyes and long antennae OR a male offspring with red eyes and short antennae?**



1. 0.03125
2. 0.28125
3. 0.31250
4. 0.59375
5. Not sure

Question from Rachel Wilson (BIOL234)

* Even if we don't say this, it's probably safe to assume this is the case

Question – probabilities - 2 traits

Relevant background information?

What the question is prompting you to do?

In the fictional insect *Cutis bugum*, eye colour and antenna length are each controlled by a **single autosomal gene** with two alleles:

- Red eyes (E) are **dominant** to green eyes (e)
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You perform a cross, creating individuals with the genotype **EeAa**. If **these individuals mate with one another**, **what is the probability they will have a female offspring with green eyes and long antennae OR a male offspring with red eyes and short antennae?**



1. 0.03125
2. 0.28125
3. **0.31250**
4. 0.59375
5. Not sure

* Even if we don't say this, it's probably safe to assume this is the case

Approach #1: Use a large Punnett square

What is the probability EeAa x EeAa will have a female offspring with green eyes (ee) and long (aa) antennae or a male offspring with red eyes (E_) and short antennae (A_) (genes unlinked)?

	EA	Ea	eA	ea
EA	EEAA	EEAa	EeAA	EeAa
Ea	EEAa	EEaa	EeAa	Eeaa
eA	EeAA	EeAa	eeAA	eeAa
ea	EeAa	Eeaa	eeAa	eeaa

Step 1: Identify the parental gametes and create a Punnett square

Step 2: Identify the relevant genotypes in the offspring:

- Female with green eyes and long antennae: XX / eeaa
- Male with red eyes and short antennae: XY / E_A_

Step 3: Calculate probabilities for each separate event.

XX / eeaa

Probability of female = $1/2^{\dagger} = 0.5$

Probability of eeaa = $1/16 = 0.0625$

Multiply

$$0.5 * 0.0625 = 0.03125$$

Multiply

Add

$$0.03125 + 0.28125 = 0.31250$$

XY / E_A_

Probability of male = $1/2 = 0.5$

Probability of E_A_ = $9/16 = 0.5625$

Multiply

$$0.5 * 0.5625 = 0.28125$$

Multiply

Add

[†] You could draw second Punnett square to figure this out or a massive 8 x 8 Punnett square, if need be.

Approach #2: Separate each trait

What is the probability EeAa x EeAa will have a female offspring with green eyes (ee) and long antennae (aa) or a male offspring with red eyes (E_) and short antennae (A_)?

Step 1:

	X	X
X	XX	XX
Y	XY	XY

	E	e
E	EE	Ee
e	Ee	ee

	A	a
A	AA	Aa
a	Aa	aa

Step 2: XX / ee / aa OR XY / E_ / A_

Step 3:

XX / ee / aa

Probability of female = $1/2 = 0.5$ Multiply $0.5 * 0.25 * 0.25$
 Probability of ee (green) = $1/4 = 0.25$ → $= 0.03125$
 Probability of aa (long) = $1/4 = 0.25$ → $0.03125 + 0.28125 =$

XY / E_ / A_

Probability of male = $1/2 = 0.5$ Multiply $0.5 * 0.75 * 0.75$
 Probability of E_ (red) = $3/4 = 0.75$ → $= 0.28125$
 Probability of A_ (short) = $3/4 = 0.75$ → **0.3125**

Learning goal

Given information about the phenotypes and/or genotypes of offspring, predict the genotypes and phenotypes of their parents

Example – using offspring genotype/phenotype to infer genotypes of the parents

Black bears (*Ursus americanus*) have a gene (called *mc1r*) controlling fur colour. The black fur (F allele) is dominant over the white fur (f allele)



Question – mother's genotype

What is the genotype of this **mother** bear (right)?

- A. FF
- B. Ff
- C. ff
- D. Cannot know from information given



Answer

What is the genotype of this **mother** bear (right)?

- A. FF
- B. Ff
- C. ff
- D. Cannot know from information given



We know that:

- The mother bear has black fur
 - The mother must carry at least one F allele
- The baby bear has white fur
 - It must be ff, so it must have received an f allele from its mother



F		
f		ff



Question – father's genotype

What is the genotype of the **father** bear (not pictured)?

- A. FF
- B. Ff
- C. ff
- D. Cannot know from information given



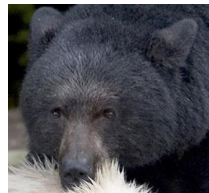
Answer

What is the genotype of the **father** bear (not pictured)?

- A. FF
- B. Ff
- C. ff
- D. Cannot know from information given



- The baby bear has white fur
 - It has to be ff, so it must have received a second f allele from its father
- The father could be Ff or ff



	?	f
F		
f		ff



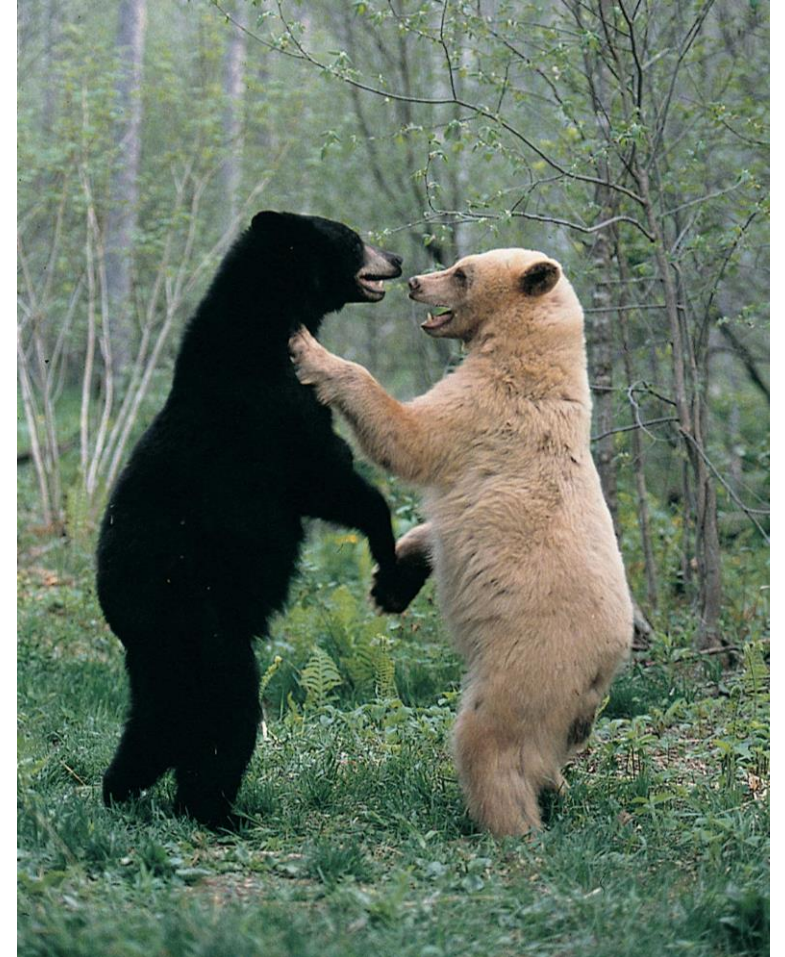
Returning to the idea of a testcross.
Using a test cross to determine the genotype of an individual with a dominant phenotype but unknown genotype

- We know a black bear has at least one F allele, but we don't know the other allele (F_)

We can perform a **TEST CROSS!**

- In a test cross, the individual with the unknown genotype is crossed with an individual that is homozygous recessive for the genes under consideration

$F_ \times ff$



iClicker Question – test cross x homozygous dominant

What are the expected phenotype frequencies (%) of the cubs if a black bear with an unknown genotype (Ff or FF ?) is crossed with a Kermode bear (ff), and the genotype of the unknown bear is homozygous dominant?



	f	f
F		
F		

- A. 100% white cubs
- B. 100% black cubs
- C. 70% black cubs, 30% white cubs
- D. 50% black cubs, 50% white cubs
- E. Not sure

Answer

What are the expected phenotype frequencies (%) of the cubs if a black bear with an unknown genotype is crossed with a Kermode bear (ff), and the genotype of the unknown bear is homozygous dominant?



	f	f
F	Ff	Ff
F	Ff	Ff

If male's genotype is FF

- A. 100% white cubs
- B. 100% black cubs**
- C. 70% black clubs, 30% white cubs
- D. 50% black cubs, 50% white cubs
- E. Not sure



iClicker Question – test cross x heterozygote

What are the expected phenotype frequencies (%) of the cubs if the black bear with the unknown genotype is **heterozygous**?



	f	f
F		
f		

- A. 100% white cubs
- B. 100% black cubs
- C. 70% black cubs, 30% white cubs
- D. 50% black cubs, 50% white cubs
- E. Not sure

Answer

What are the expected phenotype frequencies (%) of the cubs if the black bear with the unknown genotype is **heterozygous**?



	f	f
F	Ff	Ff
f	ff	ff

- A. 100% white cubs
- B. 100% black cubs
- C. 70% black cubs, 30% white cubs
- D. 50% black cubs, 50% white cubs**
- E. Not sure

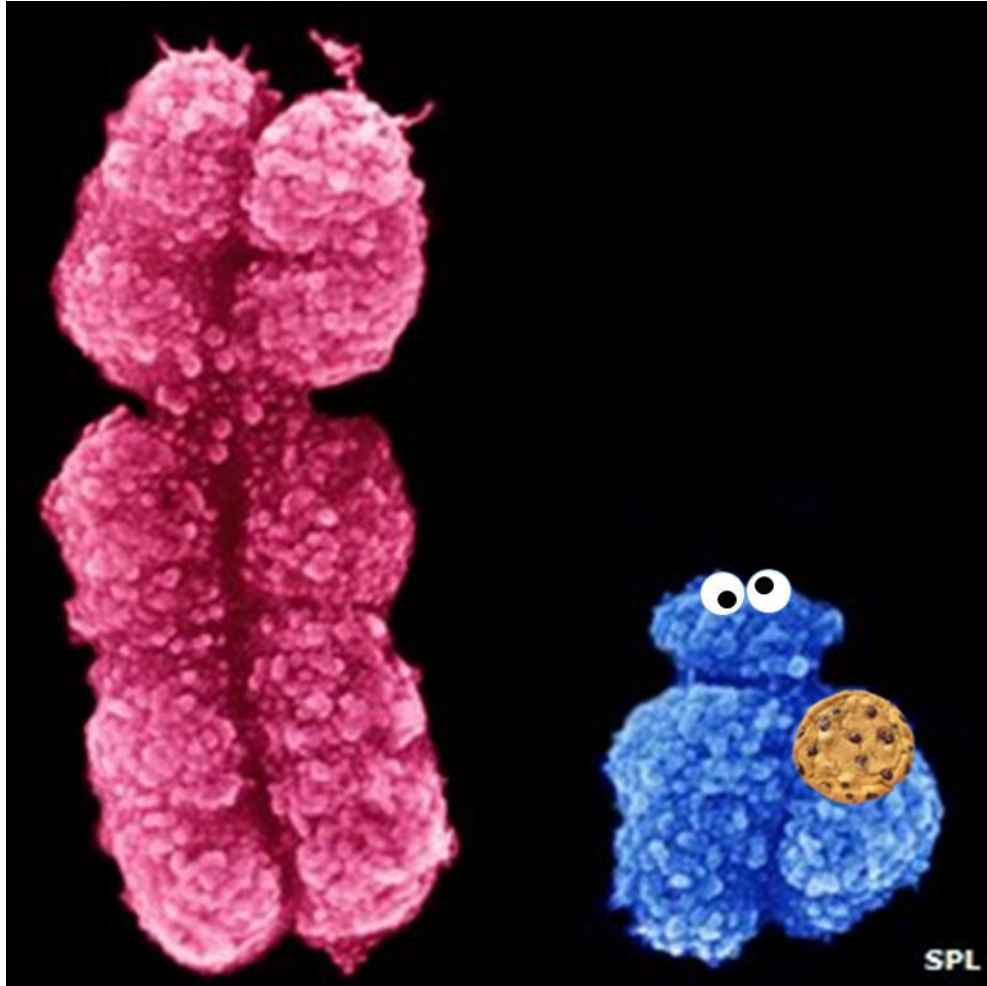
Summary - autosomal inheritance (to this point)

Offspring Phenotypic Ratio	Gene	Relationship btwn Alleles	Parents	Notes
Only one phenotype	One gene	Dominant/recessive	Parents are true-breeding (autosomal)	Outcome of Mendel's P generation crosses with peas May also see this pattern if gene is X-linked (to be explained)
One phenotype (dominant)	One gene	Dominant/recessive	Homozygous dominant individual x test cross	Bear example this lecture
3:1	One gene	Dominant/recessive	2 heterozygotes	Outcome of Mendel's F1 monohybrid crosses (heterozygotes) (peas)
9:3:3:1	Two genes, unlinked	Dominant/recessive	2 heterozygotes	Outcome of Mendel's F1 dihybrid crosses (heterozygotes) (peas)
1:1:1:1	Two genes, unlinked	Dominant/recessive	Heterozygote x test cross	Tomato example, this lecture Also tomato worksheet #4
1:1 – the original P generation phenotypes	Two genes, linked	Dominant/recessive	Heterozygote x test cross	Tomato example this lecture Also tomato worksheet #4
1:1 dominant:recessive	One gene	Dominant/recessive	Heterozygote x test cross	Bear example, this lecture - will also see if gene is X-linked (to be explained)

Learning goals

- Be familiar with offspring genotype and phenotype patterns when genes are on an autosome.
- Be able to predict what gamete genotypes an individual can produce when the gene is autosomal (one and two traits).
- If given information about the genotype and/or phenotype of parents, be able to predict offspring genotypes and phenotypes and in what frequencies/ratios for genes that are on an autosome.
- If given information about the genotype/phenotype of offspring, be able to make inferences about parental genotypes.
- Be able to calculate the probability that two parents will have an offspring with a specific genotype/phenotype (one and two traits)

X-linked dominant and recessive modes of inheritance



Sex-linked* traits exhibit different patterns of inheritance

* Important: “Sex linkage” means something different than “physical linkage”

- The gene in question is located on one of the sex chromosomes (X or Y)
 - We would call these genes either X-linked or Y-linked

More about sex chromosomes (X and Y) – not testable

X chromosome

- ~150 million base pairs (bigger than Y chromosome)
- 800+ genes
 - Many are essential for development and cognition
 - e.g. Apoptosis-inducing factor (programmed cell death)

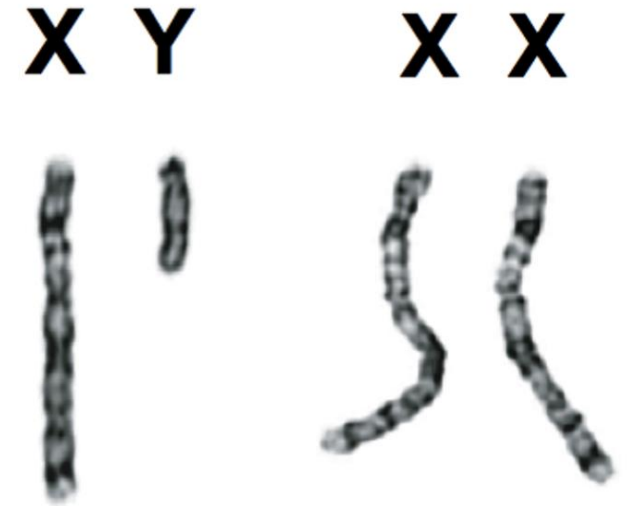
Y chromosome

- ~ 57 million base pairs
- 100-200 genes
 - e.g. SRY gene (male sex determination)

Fun fact: platypuses have TEN sex chromosomes!!

- E.g., a male platypus has the karyotype

$X_1Y_1X_2Y_2X_3Y_3X_4Y_4X_5Y_5$



Patterns for X-linked traits?

It depends on whether the dominant allele is on the X-chromosome of the mother or father

For simplicity, we will call XX individuals “female” and XY individuals “male”, but remember that sex phenotypes can be more complex and are not entirely determined by chromosomes.

An acknowledgement of the language used in the genetic unit of this course

In this part of the Genetics Unit – I will refer to individuals with an XY genotype as males and an XX genotype as females.

But, an individual's biological sex (sex assigned at birth) is not just determined by chromosomes.

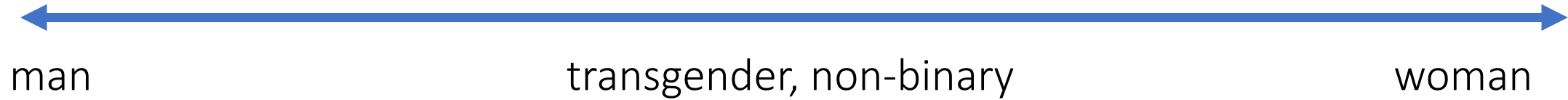
It is also determined by an individual's physiology (e.g., sensitivity to testosterone and cortisol production).

So sex is not binary, but rather a continuum.



An acknowledgement of the language used in the genetic unit of this course

Gender identify is also a continuum



The language that we will be using in class is a reflection of historical contingency (e.g. daughter cells), but it is changing.

It is very important to me that I create a learning environment where everyone feels included and respected.

If you have any feedback or suggestions in this regard, please let me know!!

Next class, due Sunday night

Next class:

- X-linked patterns of inheritance
- Non-dominance
- Using genetic crosses to infer mode of inheritance for a trait

Due this Sunday night

- Quiz 3 (Inheritance of Traits – Mendel & the Gene)
- Worksheet #3 – Sally scenario (mitosis and meiosis)
- Worksheet #4 – Tomato Crosses