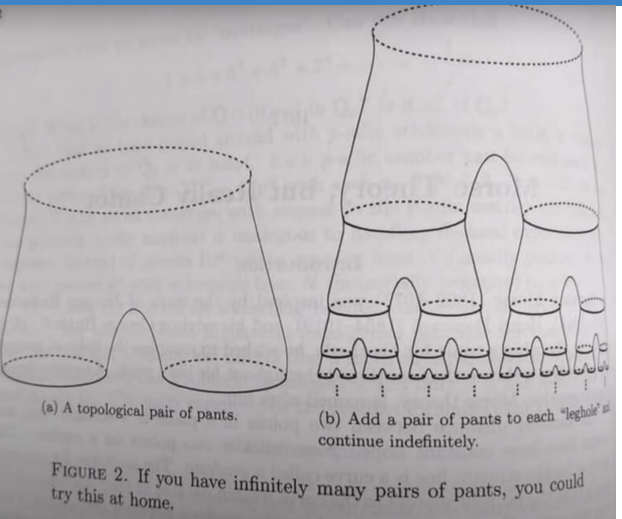
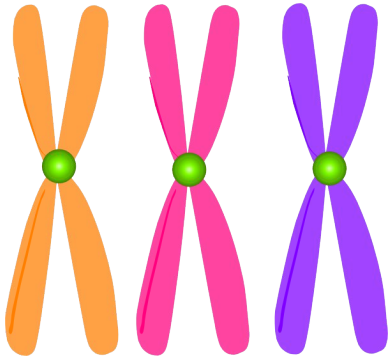
Febr. 4th, 2023

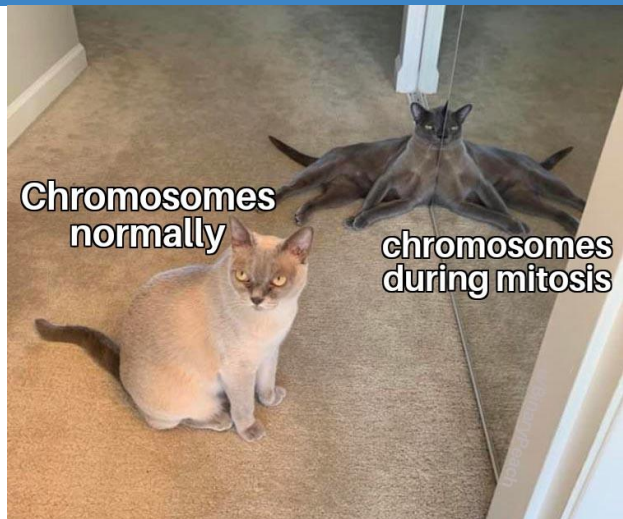
BIOL 121

Genetics Review Session

with Ruby and Christie!







How are you feeling about the upcoming midterm?

So ready. Gonna ace this, just getting all the review I can.

What happens happens, at this point :/

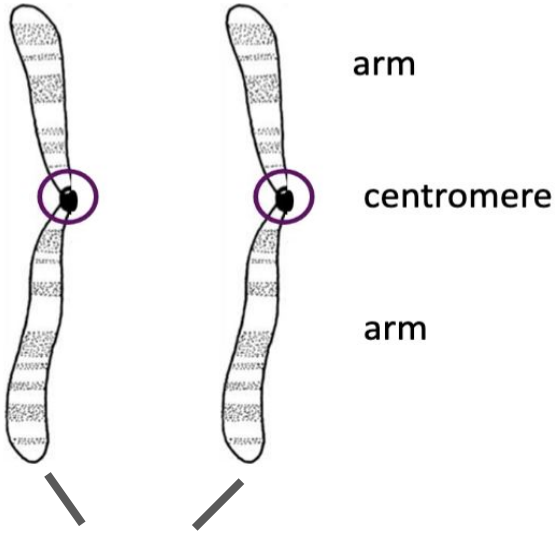
Why do you think I’m at the midterm review :(((((((

Chromosomes & Cell Cycle Review

Tip: one centromere = one chromosome!

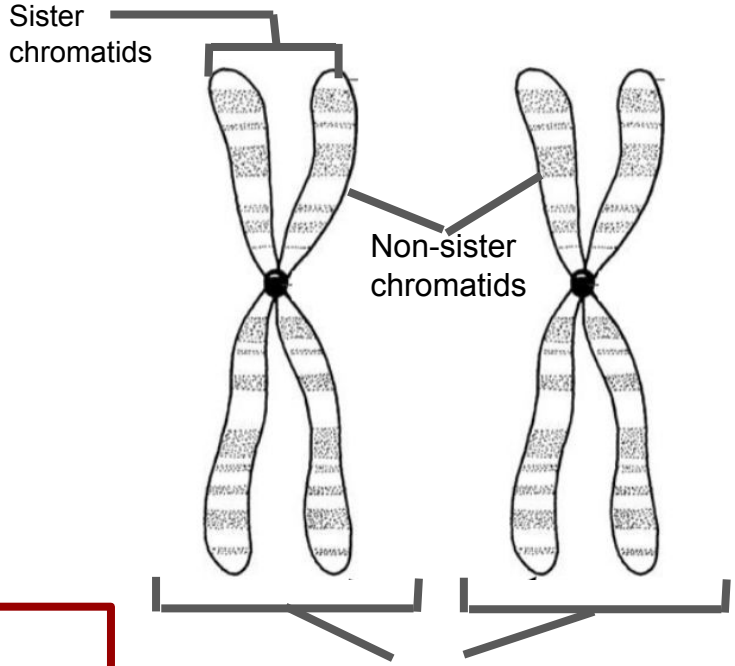
(Diagrams are from class slides!)

Unreplicated Chromosomes
(Before S phase, or after anaphase)



Homologous chromosomes

Replicated Chromosomes
(After S phase, before anaphase)



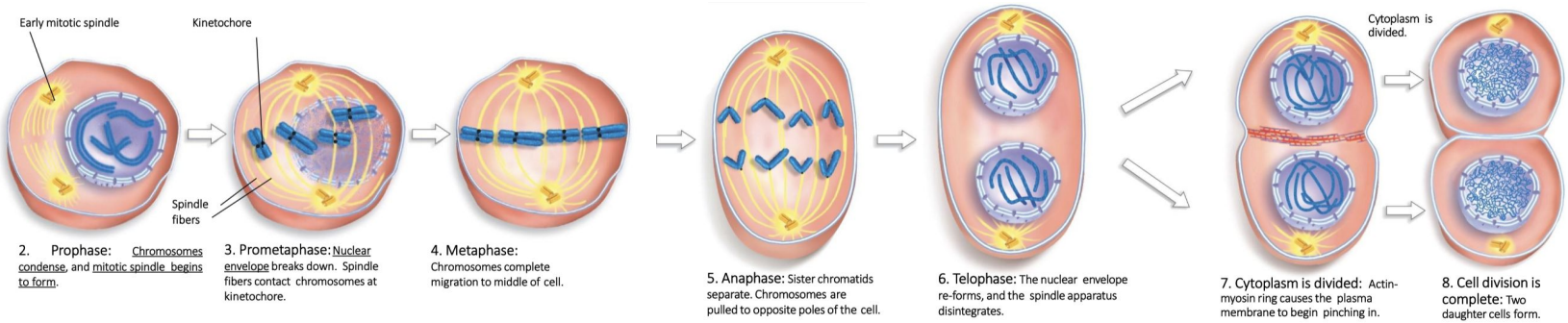
Homologous chromosomes

Remember!
An unreplicated chromosome has 1 DNA molecule
A replicated chromosome has 2 DNA molecules

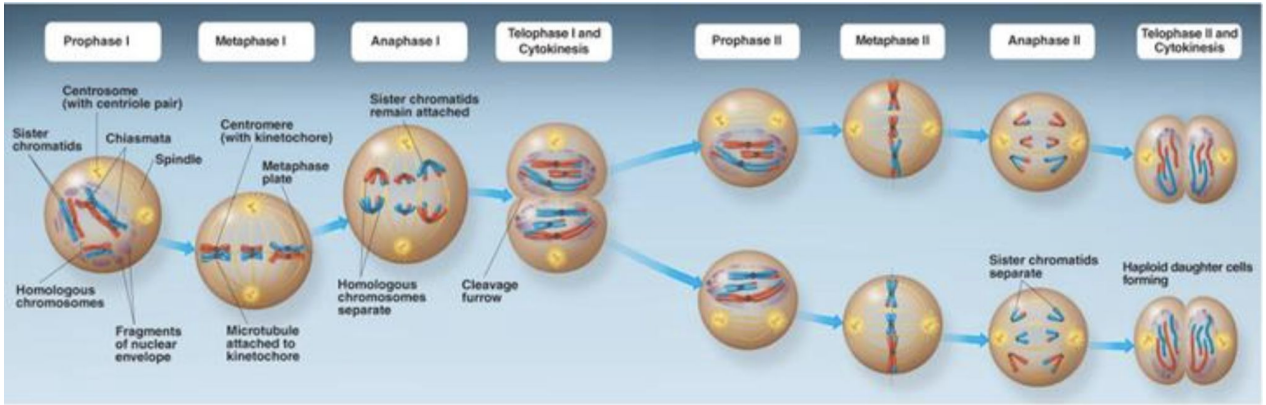
Chromosomes & Cell Cycle Review

(Diagrams are from class slides!)

Mitosis: Produce 2 genetically identical daughter cells, maintain ploidy



Meiosis: Produce 4 genetically different daughter cells, reduce ploidy



Amount of DNA (Annotate!)

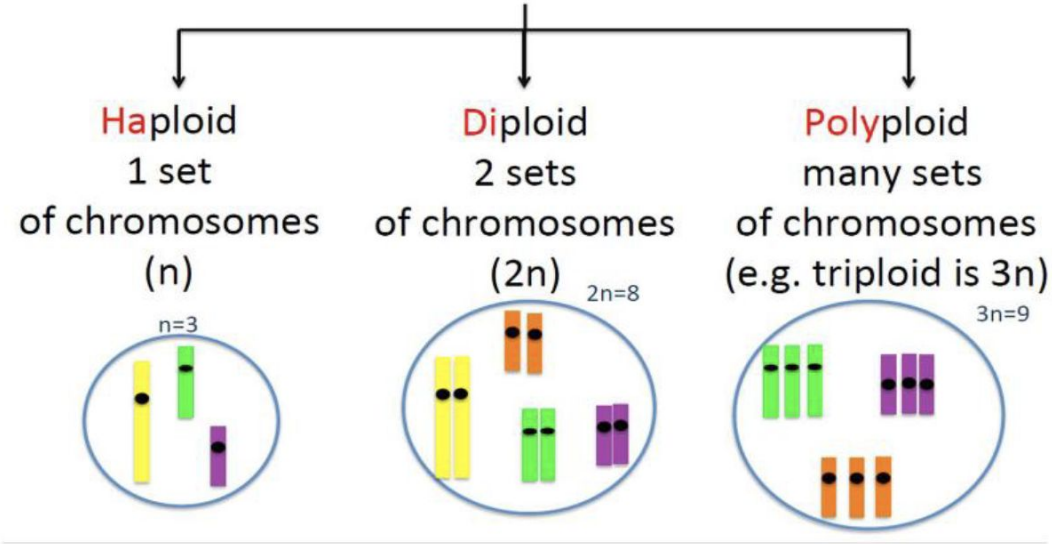
- What can cause the amount of DNA in a cell to **double**?

- What can cause the amount of DNA in a cell to be reduced by **half**?

- Which phases of the cell cycle and mitosis don't change the amount of DNA in the cell? (Circle all that apply!) relative to the phase before it

G1 S G2 Prophase Metaphase Anaphase Telophase Cytokinesis

Ploidy

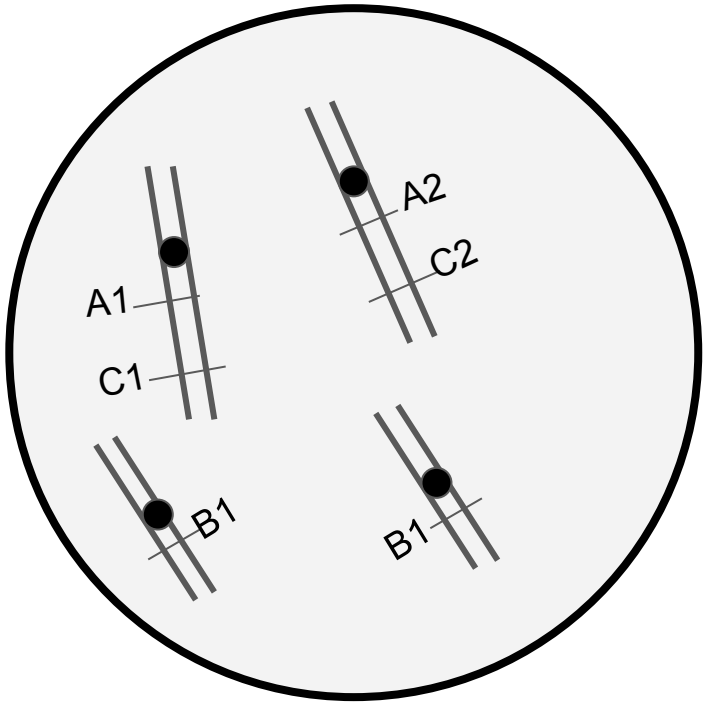


Haploid number (n) is the number of chromosomes in a **gamete**

- **Diploid** organisms produce **haploid gametes**. This is the point of meiosis!

Homologs are chromosomes that code for the **same genes** (but not necessarily alleles). Always the **same size** and **same centromere placement**!

Cell Cycle Question 1



Haploid or **Diploid** or **Triploid** ?

__n = ___

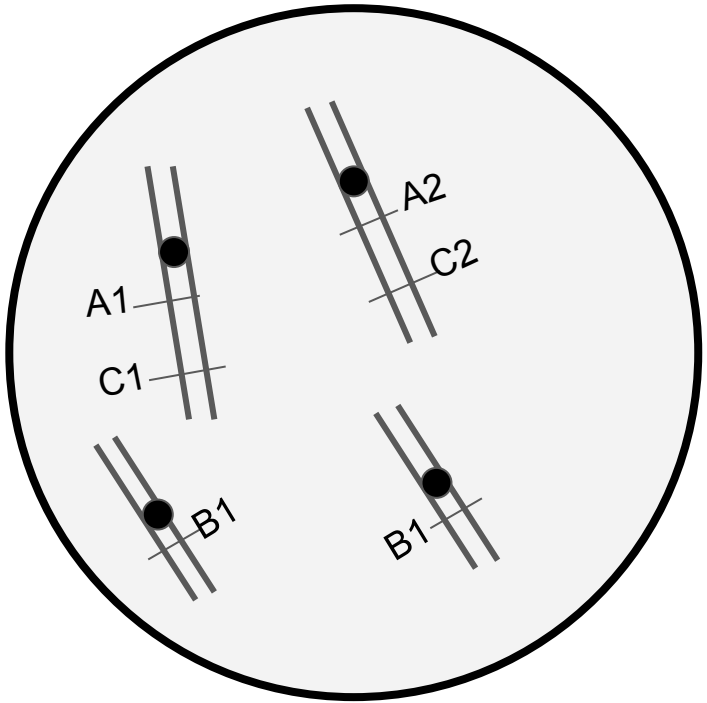
Gamete genotypes if…

No crossing over?

Crossing over?

Cell Cycle Question 1

* remember the 2^n rule! Gives you the number of possible genotypes based on the number of heterozygous genes (n) when crossing over is allowed



Haploid or **Diploid** or **Triploid** ?

2n = 4

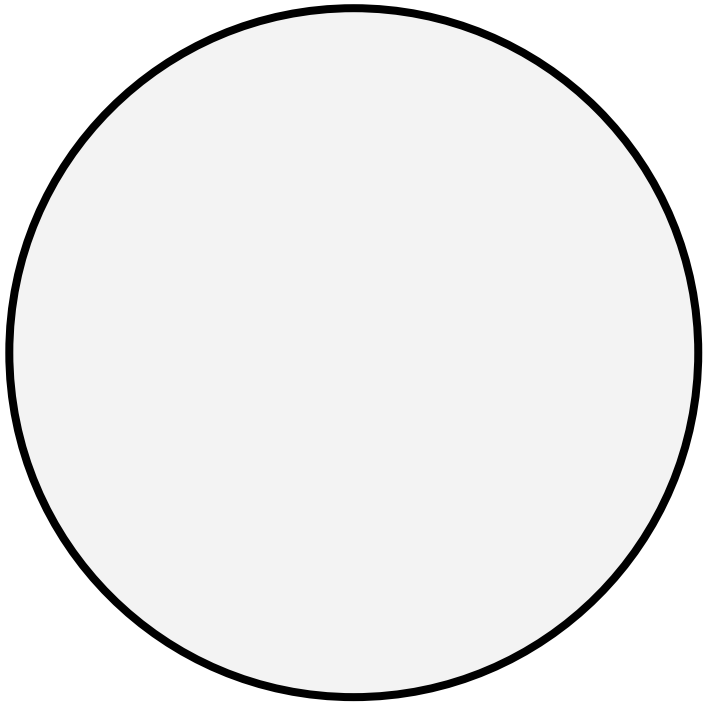
Gamete genotypes if…

No crossing over? A1C1B1, A2C2B1

*Crossing over? A1C1B1, A2C2B1, A1C2B1, A2C1B1

Bonus: if the A and C genes are tightly linked but crossing over can still happen, which gametes will be more common?

Cell Cycle Question 2



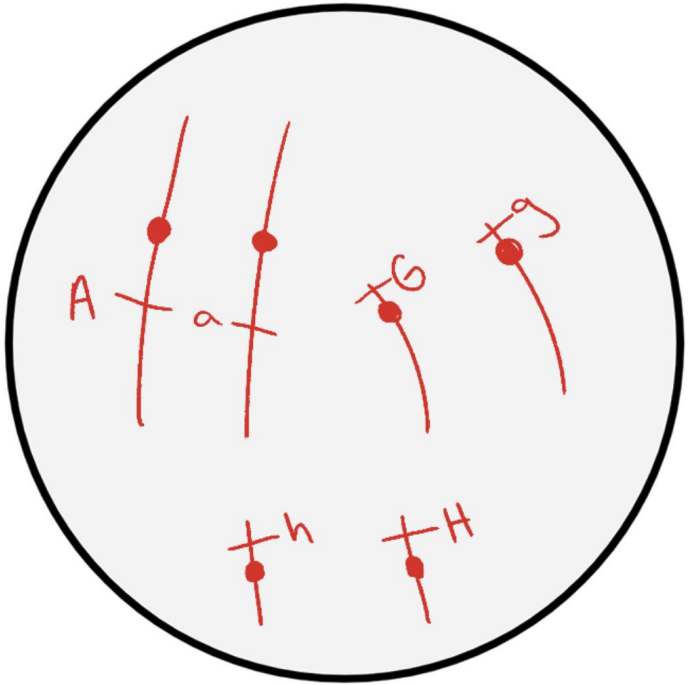
Draw a **diploid** cell in **G1**.

2n = 6

Label the alleles **A, a, G, g, H, h**

with no linkage!

Cell Cycle Question 2



Draw a **diploid** cell in **G1**.

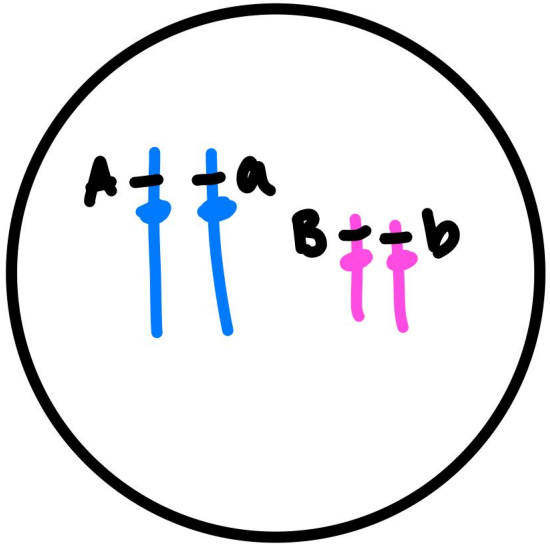
2n = 6

Label the alleles **A, a, G, g, H, h**

with no linkage!

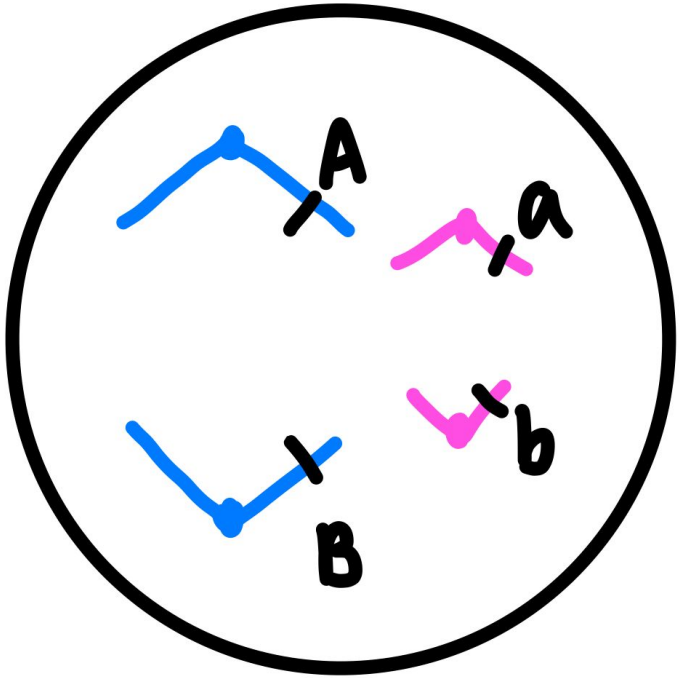
Check: are the alleles of the same gene at the same locus? Are the chromosomes unreplicated? Are there two of each chromosome?

Cell Cycle Question 3 (2n = 4)



G1 Phase

Cell Cycle Question 3a (2n = 4)



Given this scenario, identify:

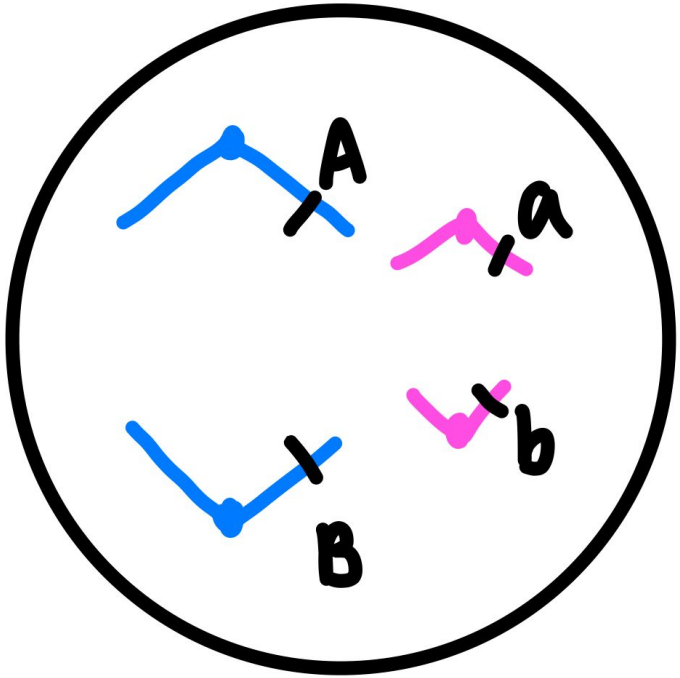
Mitosis/Meiosis(I or II)/Impossible?

_____

Which stage (if applicable)?

_____

Cell Cycle Question 3a (2n = 4)



Given this scenario, identify:

Mitosis/Meiosis(I or II)/Impossible?

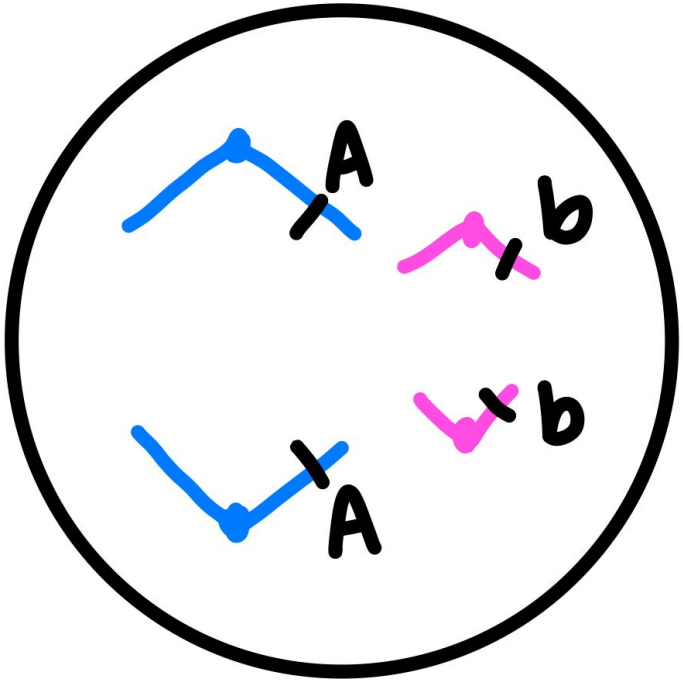
Impossible

Which stage (if applicable)?

n/a

Why? Different genes can not be located in the exact same location as one another on what was previously (in “metaphase”) a replicated chromosome.

Cell Cycle Question 3b (2n = 4)



Given this scenario, identify:

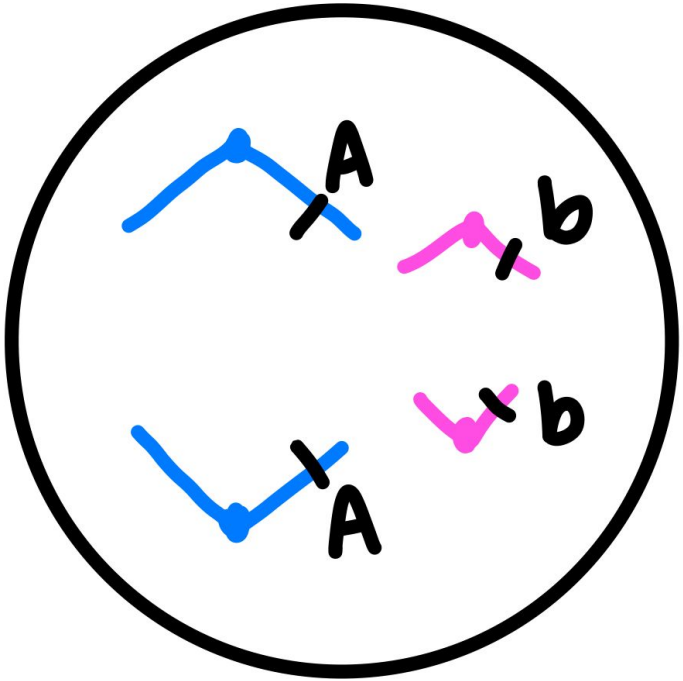
Mitosis/Meiosis(I or II)/Impossible?

_____

Which stage (if applicable)?

_____

Cell Cycle Question 3b (2n = 4)



Given this scenario, identify:

Mitosis/Meiosis(I or II)/Impossible?

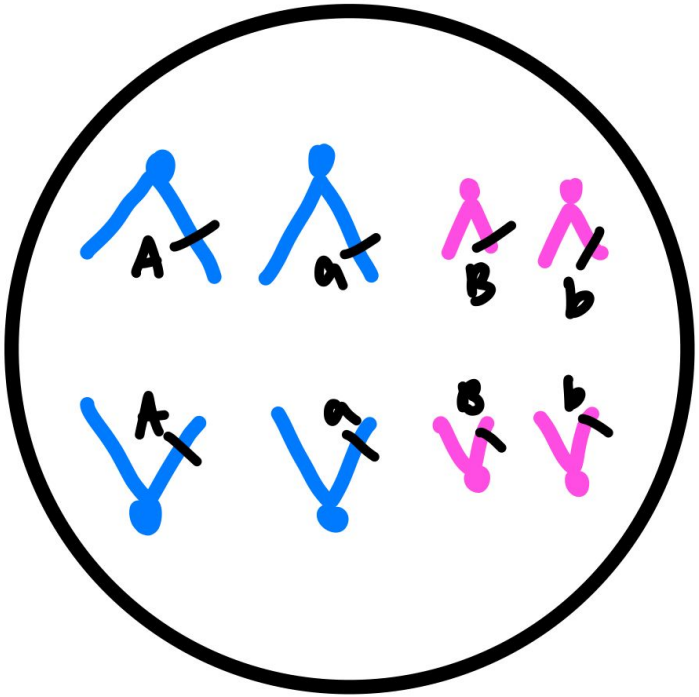
Meiosis II

Which stage (if applicable)?

Anaphase

Why? Once division occurs here, 2 cells will form with each cell having 2 chromosomes. This is half the number of chromosomes we started with, therefore this cell is in meiosis II. Sister chromatids are separating here, therefore it's anaphase!

Cell Cycle Question 3c (2n = 4)



Given this scenario, identify:

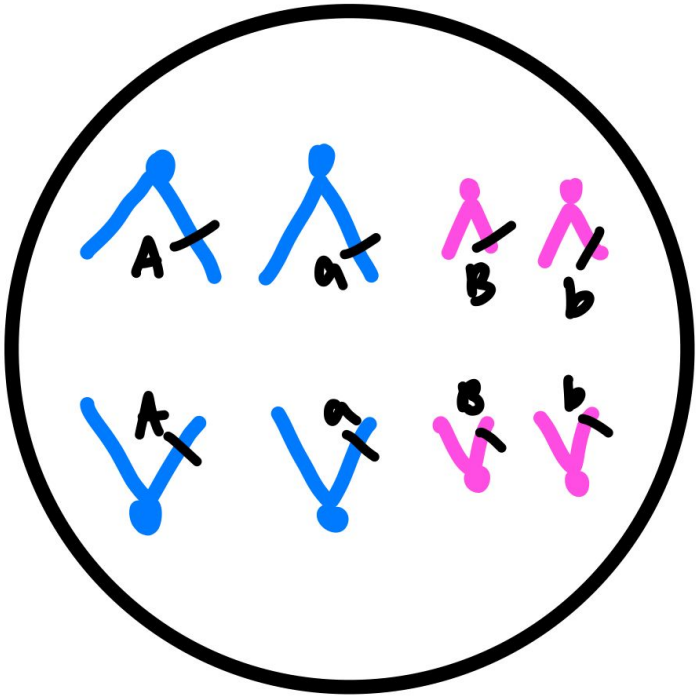
Mitosis/Meiosis(I or II)/Impossible?

_____

Which stage (if applicable)?

_____

Cell Cycle Question 3c (2n = 4)



Given this scenario, identify:

Mitosis/Meiosis(I or II)/Impossible?

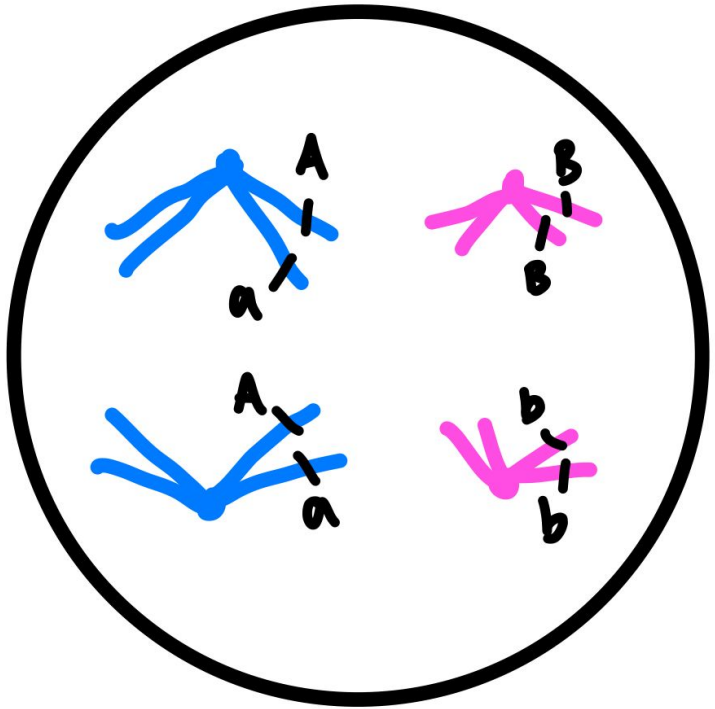
Mitosis

Which stage (if applicable)?

Anaphase

Why? Once this cell divides, there will be two resulting cells and each cell will have 4 chromosomes. This matches G1 phase and therefore must come from mitosis. Again, sister chromatids are separating here and so it's anaphase. All genes and alleles are positioned on their respective chromosome correctly.

Cell Cycle Question 3d (2n = 4)



Given this scenario, identify:

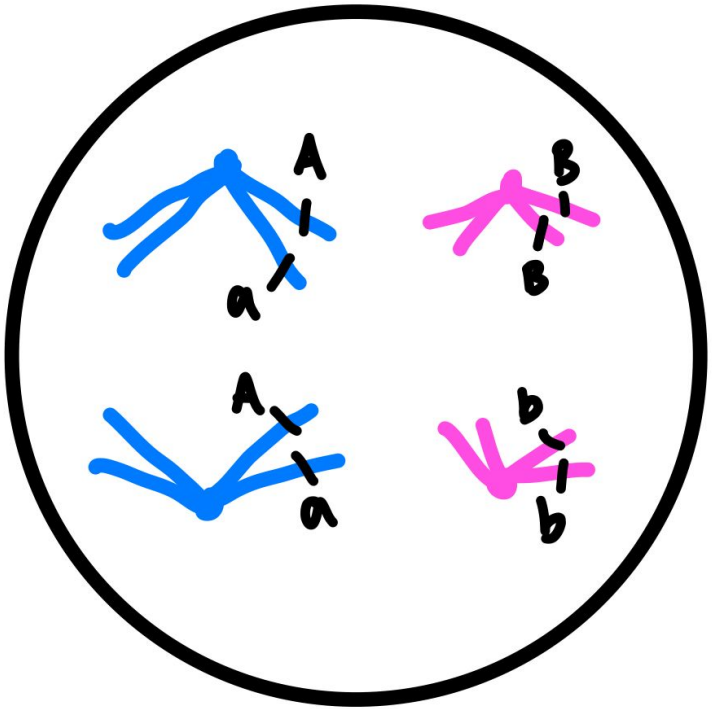
Mitosis/Meiosis(I or II)/Impossible?

_____

Which stage (if applicable)?

_____

Cell Cycle Question 3d (2n = 4)



Given this scenario, identify:

Mitosis/Meiosis(I or II)/Impossible?

Meiosis I

Which stage (if applicable)?

Anaphase

Why? Homologous chromosomes are separating, and this only occurs in Meiosis I.

*Bonus: How is it possible that replicated chromosomes have different alleles of the same gene (ex. Blue chromosome)?

Genetic Crosses and Inheritance Review

Alleles can be **dominant** or **recessive** to each other, and may be found on autosomal chromosomes or sex chromosomes.

Recessive alleles can be ‘hidden’ by **dominant** alleles - heterozygotes will resemble homozygous dominant individuals.

Aa = AA ≠ aa, in terms of phenotype for that trait

X-linked alleles may result in **female offspring having different phenotype ratios than male offspring (sex bias)**. This difference may appear in the F1 or F2 generation.

Females get X from both parents, males only get X from mother

Two alleles may not be dominant to each other - this is **non-dominance**. In this case, **heterozygotes have a unique phenotype**.

A1A1 ≠ A1A2 ≠ A2A2, in terms of phenotype for that specific trait

Genetic Crosses and Linkage Review

If genes are on the **same chromosome**, they are **linked**. The **closer** the genes are to each other, the **less likely** crossing over is to happen between them, and the frequency of recombinant genotypes **decreases**

Recombinant genotypes are genotypes different from parental gamete genotypes! Can happen from:

- Crossing over (genes are linked)
- Independent assortment (genes on separate chromosomes)

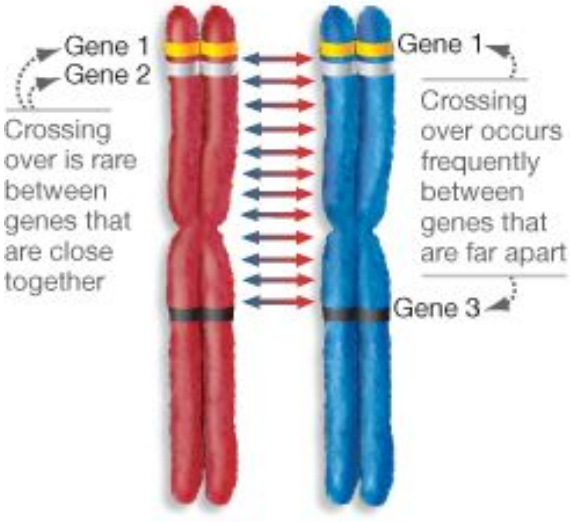


Figure out the parental genotypes based on the **parents' phenotypes** (if showing **recessive** trait), or from **offspring ratios** (parental will be more common)

Freeman, S., Allison, L., Black, M., Podgorski, G., Quillin, K., Carmichael, J., Taylor, E., Harrington, M., & Sharp, J. (2019). *Biological Science* (3rd Canadian). Pearson Canada Inc.

Monohybrid cross: result ratios

It helps to know common genotype and phenotype ratios to intuit parent genotypes.

Case 1: A is dominant, a is recessive

	AA x aa	**AA x Aa**	**Aa x Aa**
Genotype:	100% Aa	1 AA : 1 Aa	1 AA : 2 Aa : 1 aa
Phenotype:	100% Dominant	100% Dominant	3 Dominant : 1 Recessive

Case 2: A1 and A2 are alleles that are non-dominant

	A1A1 x A2A2	**A1A1 x A1A2**	**A1A2 x A1A2**
Genotype:	100% A1A2	1 A1A1 : 1 A1A2	1 A1A1 : 2 A1A2 : 1 A2A2
Phenotype:	100% Intermediate	1 A1 trait : 1 Intermediate	1 A1 trait : 2 Intermediate : 1 A2 trait

Tip 1: Pay attention to when you're referring to genotype or phenotype!

Tip 2: For questions with >1 gene, you can still go gene by gene and look for these ratios!

Probability Rules!

Sum rule: “or” “either”

- Add probabilities

Ex. brown eyes **or** blue eyes

Multiplication rule: “and”

- Multiply probabilities

Ex. brown eyes **and** female

Genetic Cross Question 1, pt 1

Highland unicorns are known for their lovely, fuzzy ears. We know that long ears are dominant to short ears, and red fur is dominant to blonde fur.

You conduct the following cross:

Short eared cow with blonde fur x Long eared cow with red fur

The red cow has had blonde offspring with short ears before. Assuming no linkage, what phenotypic and genotypic ratios do you expect in the offspring?

Genetic Cross Question 1

Let E be the long ears allele. Let e be the short ears allele.

Let F be the red fur allele. Let f be the blonde fur allele.

Phenotypes:
(given)

Short eared cow with blonde fur x Long eared cow with red fur

Genotypes:

eeff

EeFf

The red cow has had calves with both recessive traits, meaning it must be heterozygous for both genes!

	E	e
e	Ee	ee
e	Ee	ee

G: 50% Ee, 50% ee
P: 50% long ears, 50% short ears

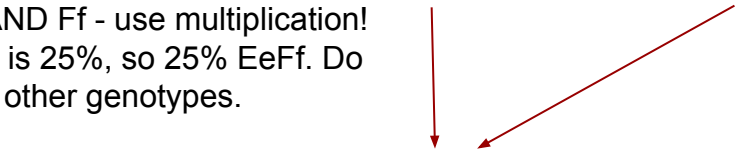
	F	f
f	Ff	ff
f	Ff	ff

G: 50% Ff, 50% ff
P: 50% red fur, 50% blonde fur

Genetic Cross Question 1

50% Ee, 50% ee. 50% Ff, 50% ff.

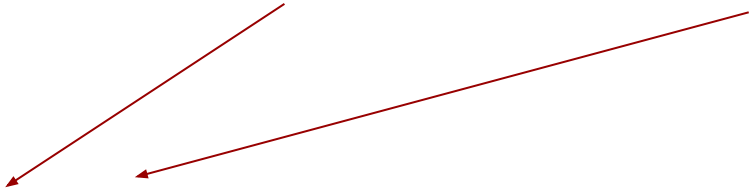
Probability Ee AND Ff - use multiplication! 50% times 50% is 25%, so 25% EeFf. Do the same for all other genotypes.



25% EeFf, 25% Eeff, 25% eeFf, 25% eeff.

50% long ears, 50% short ears. 50% red fur, 50% blonde fur.

Same thing - use the multiplication rule to get phenotype ratios!



25% long ear red fur, 25% long ear blonde fur, 25% short ear red fur, 25% short ear blonde fur.

Genetic Cross Question 1 pt 2

To your surprise, the actual offspring ratios look something like this:

- 15% EeFf (long ears red fur)
- 35% Eeff (long ears blonde fur)
- 35% eeFf (short ears red fur)
- 15% eeff (short ears blonde fur)

How is this possible?

Genetic Cross Question 1 pt 2

To your surprise, the actual offspring ratios look something like this:

- 15% EeFf (long ears red fur)
- 35% Eeff (long ears blonde fur)
- 35% eeFf (short ears red fur)
- 15% eeff (short ears blonde fur)

How is this possible? The ear length and fur colour genes must be linked (ie. on the same chromosome) !

Which genotypes/phenotypes are parental, and which ones are recombinant?

Genetic Cross Question 1 pt 2

To your surprise, the actual offspring ratios look something like this:

- 15% EeFf (long ears red fur)
- 35% Eeff (long ears blonde fur)
- 35% eeFf (short ears red fur)
- 15% eeff (short ears blonde fur)

BONUS: Draw a somatic cell of the red fur long eared parent, labelling the alleles on the chromosomes. How do you know which alleles go together?

How is this possible? The ear length and fur colour genes must be linked (ie. on the same chromosome) !

Which genotypes/phenotypes are parental, and which ones are recombinant?

Eeff (long ears blonde fur) and eeFf (short ears red fur) are parental, while the others are recombinant. We know this because if the genes are linked, we will only get recombinant genotypes when crossing over occurs between the E and F genes, which will not always happen. This means some genotypes will have a frequency lower than expected, and they must be recombinant.

Genetic Cross Question 2

Clowns are known for their noses and smiles. Assume that nose colour and smile type are determined by different genes. The possible nose colours are red and yellow and the possible smile types are smile and frown. You perform a cross between pure-breeding clowns: a red-nosed smiling male clown and a yellow-nosed frowning female clown. The results are summarized below:

F1:

16 yellow-nosed smiling males
15 red-nosed smiling females

If the F1 are crossed with each other, predict the proportion of F2 offspring that will be yellow-nosed and smiling. Show your work.

Genetic Cross Question 2

F1:

16 yellow-nosed smiling males
15 red-nosed smiling females

- Note that parents of F1 are pure-breeding
- Observe that all F1 are smiling → indicates that smiling is dominant to frowning. Trait cannot be X-linked, as F1 males would then be frowning.
- Observe that all F1 males are yellow-nosed and all F1 females are red-nosed → nose colour likely an X-linked trait

Genetic Cross Question 2

F1:

16 yellow-nosed smiling males
15 red-nosed smiling females

- Create Punnett squares for each trait → recommended that you make separate squares for each trait
- Assign alleles for smile type and nose colour: e.g. A and a for smile type and X^1 and X^2 for nose colour
- Remember that we know from the F1 that smiling is dominant to frowning so A is the smiling allele and a is the frowning allele
- Let X^1 be yellow-nosed and X^2 be red-nosed

Genetic Cross Question 2

F1:

16 yellow-nosed smiling males
15 red-nosed smiling females

- First we'll look at smile type
- Since F1 parents were pure-breeding, F1 must have Aa genotype
- Draw a Punnett square for the F2

	A	a
A	AA	Aa
a	Aa	aa

Genetic Cross Question 2

	A	a
A	AA	Aa
a	Aa	aa

- Remember that smiling is dominant to frowning and the question asked for the proportion of smiling F2
- If you do the calculation, ¾ or 75% of the F2 will be smiling

Genetic Cross Question 2

F1:	
	16 yellow-nosed smiling males
	15 red-nosed smiling females

- Next we'll look at nose colour
- All F1 males are yellow-nosed and all F1 females are red nosed
- We can draw a Punnett square for the F1 to make the dominant X-linked trait more clear
- Let X^1 be yellow-nosed and X^2 be red-nosed

F1:	X^1	X^1
X^2	X^1X^2	X^1X^2
Y	X^1Y	X^1Y

Genetic Cross Question 2

F1:	X^1	X^1
X^2	X^1X^2	X^1X^2
Y	X^1Y	X^1Y

- Based on the Punnett square above for the F1, red-nosed (X^2) is dominant to yellow-nosed (X^1) since the F1 females were all heterozygotes with red noses.
- Draw a Punnett square for the F2

F2:	X^1	X^2
X^1	X^1X^1	X^1X^2
Y	X^1Y	X^2Y

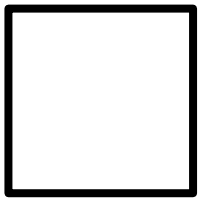
Genetic Cross Question 2

F2:	X^1	X^2
X^1	X^1X^1	X^1X^2
Y	X^1Y	X^2Y

- The question asks for the proportion of yellow-nosed F2
- If you do the calculation, 2/4 or 50% of F2 will be yellow-nosed
- We are interested in the proportion of F2 that are yellow-nosed AND smiling
- 0.75 (from the previous slide on smile type) * 0.5 = 0.375 = 37.5%
- Therefore, 37.5% of F2 will be yellow-nosed and smiling

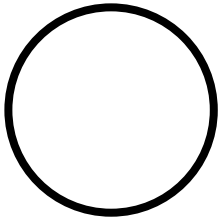
Pedigree review

- A family tree that shows inheritance of a specific trait
- Can show a trait inherited **autosomally** or **X-Linked**, and **dominant** or **recessive**. Learn the patterns!
- Work through hypothesized mode of inheritance, assigning alleles until it is complete or a part is impossible

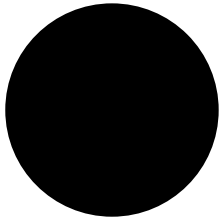


Unaffected male

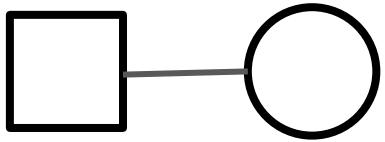
Affected male



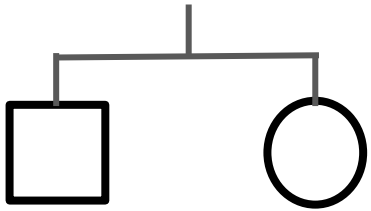
Unaffected female



Affected female



Mating

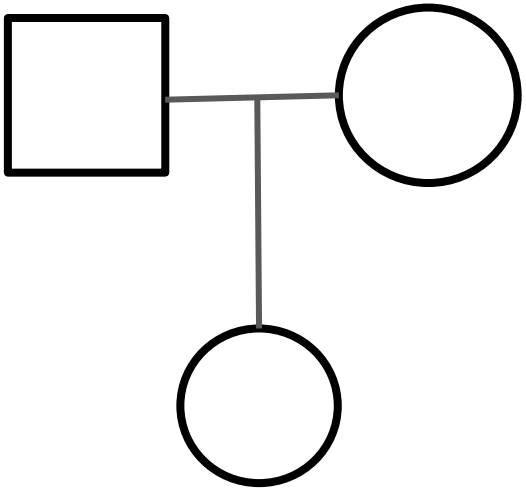


Siblings

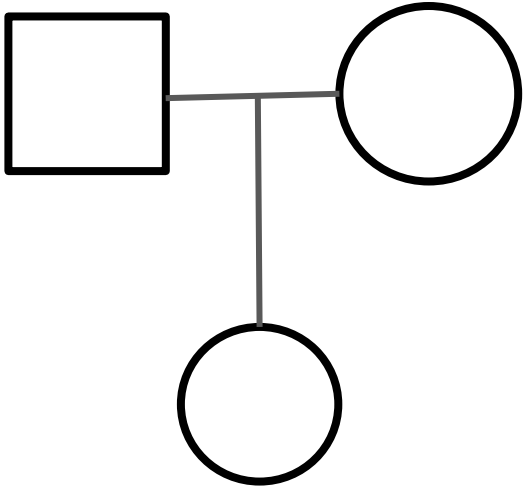
Tip: when referring to specific individuals, use the number under their symbol! (See an upcoming slide for an example)

Pedigree patterns-

Use the annotate tool to fill in the individuals so that the inheritance type **must** be the one listed!



Dominant



Recessive

Pedigree Question

Which of these modes of inheritance are possible?

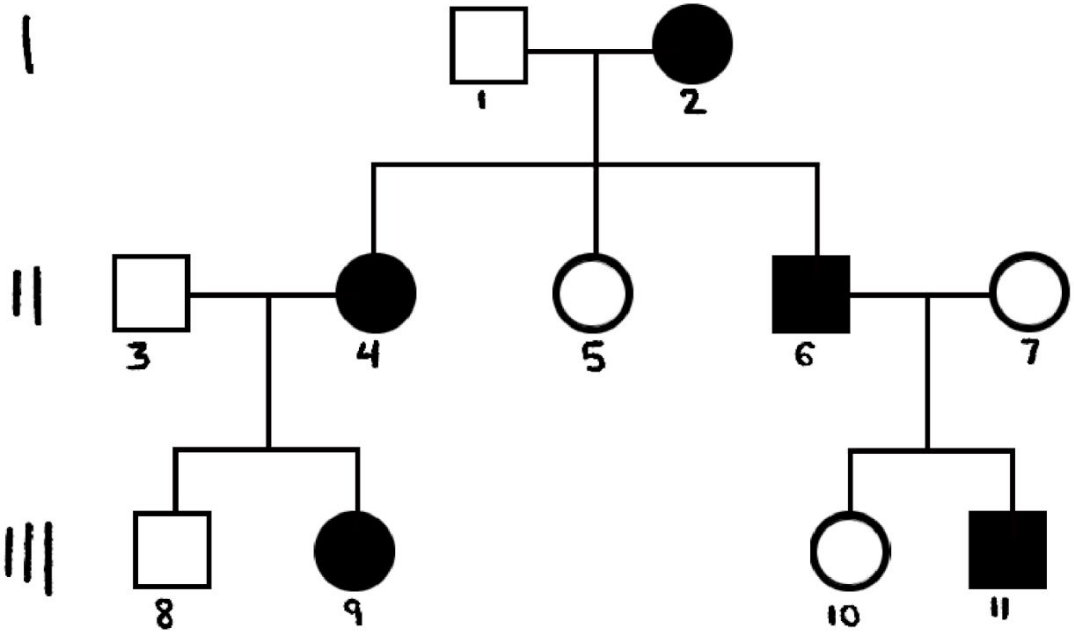
For the impossible ones, explain what makes them impossible.

Autosomal Dominant

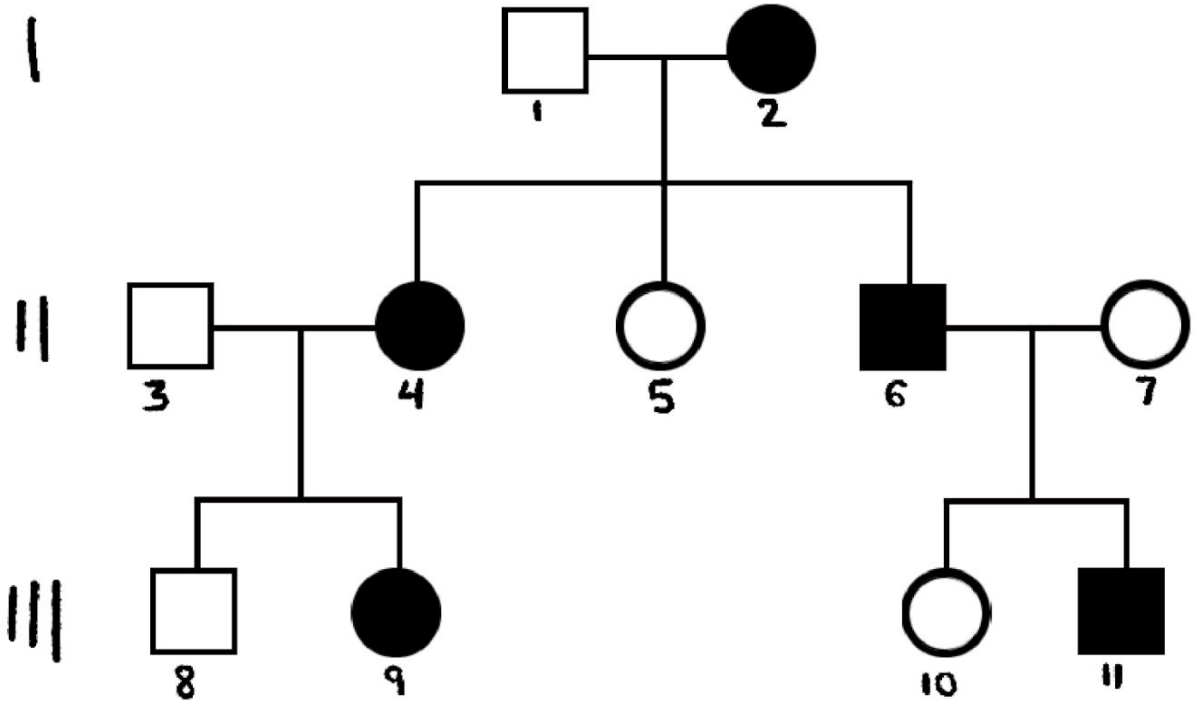
Autosomal Recessive

X-Linked Dominant

X-Linked Recessive



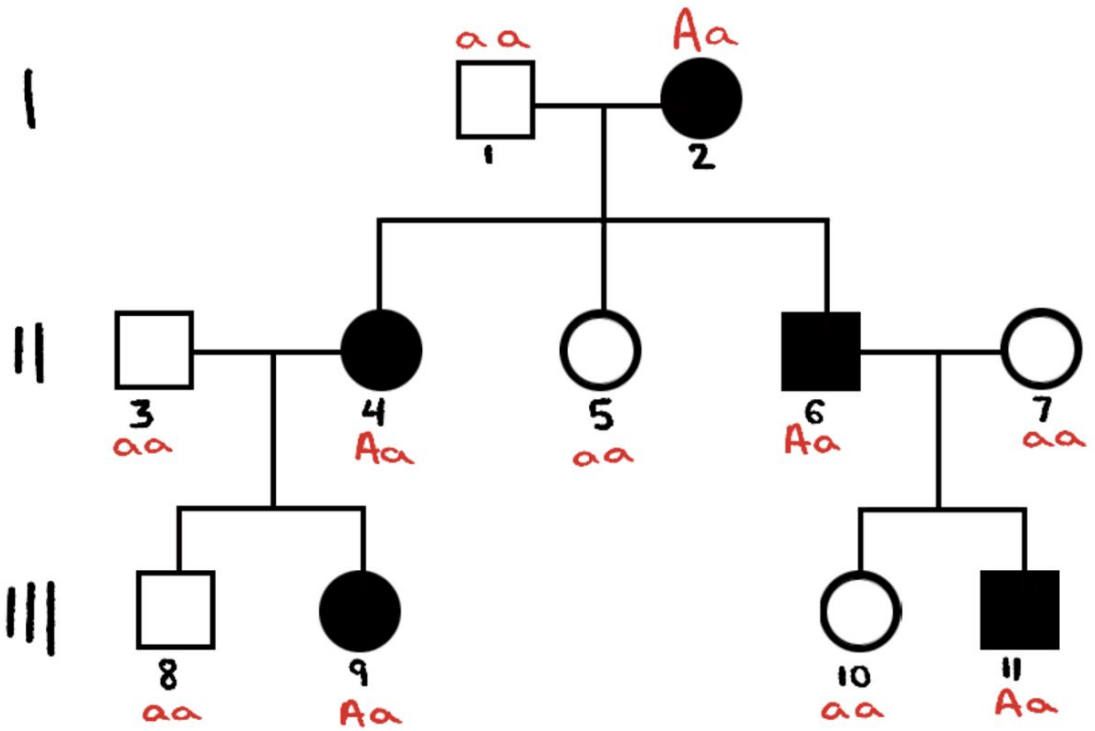
Autosomal Dominant?



A = affected

a = unaffected

Autosomal Dominant? POSSIBLE



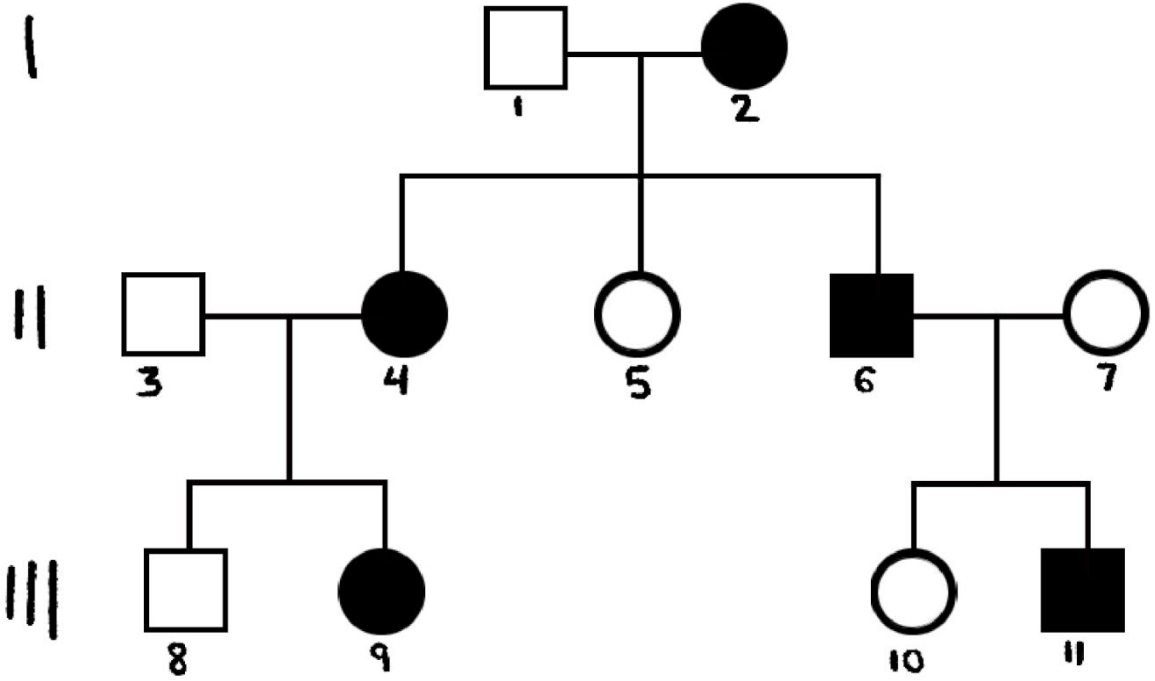
A = affected

a = unaffected

How do we know individual 2 is heterozygous?

How do we know individuals 4 and 6 are heterozygous?

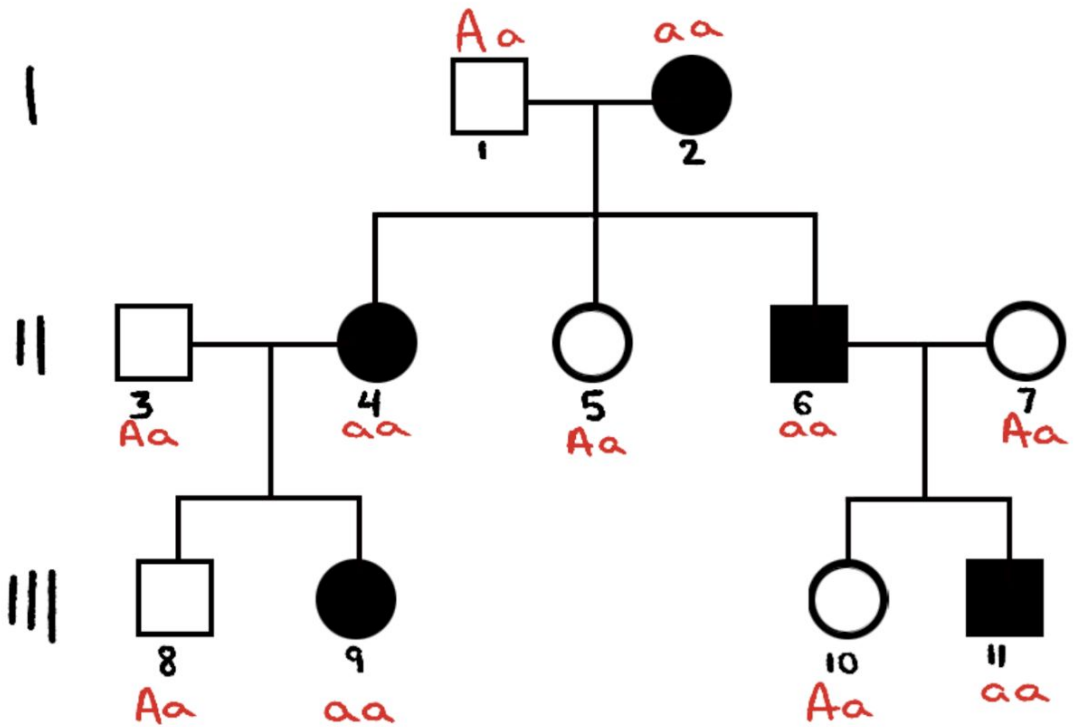
Autosomal Recessive?



a = affected

A = unaffected

Autosomal Recessive? POSSIBLE



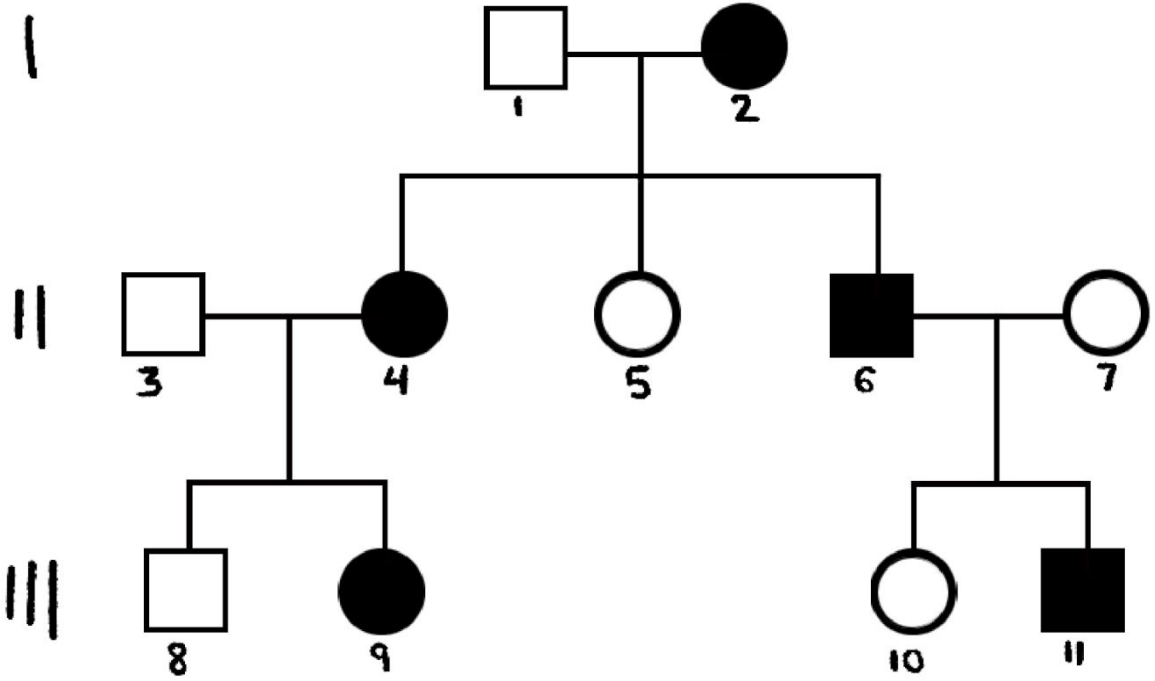
a = affected

A = unaffected

How do we know ind. 1 is heterozygous?

How do we know ind. 5 is heterozygous?

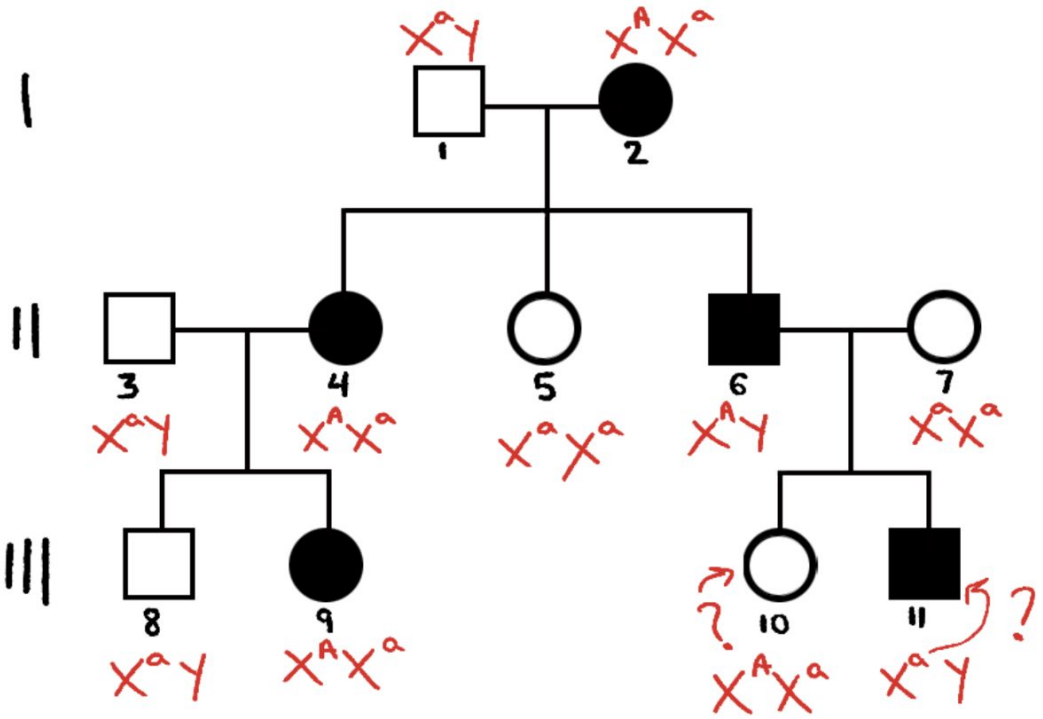
X-Linked Dominant?



X^A = affected

X^a = unaffected

X-Linked Dominant? IMPOSSIBLE

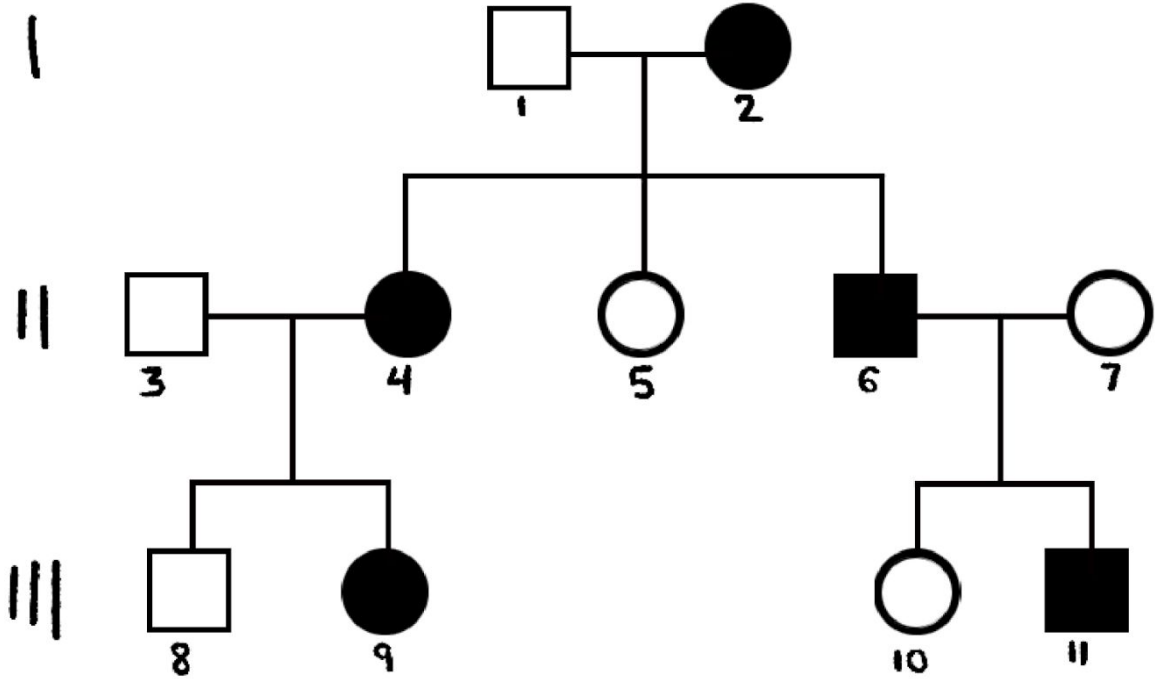


X^A = affected

X^a = unaffected

What should the phenotypes of ind. 10 and 11 be if this mode of inheritance were correct?

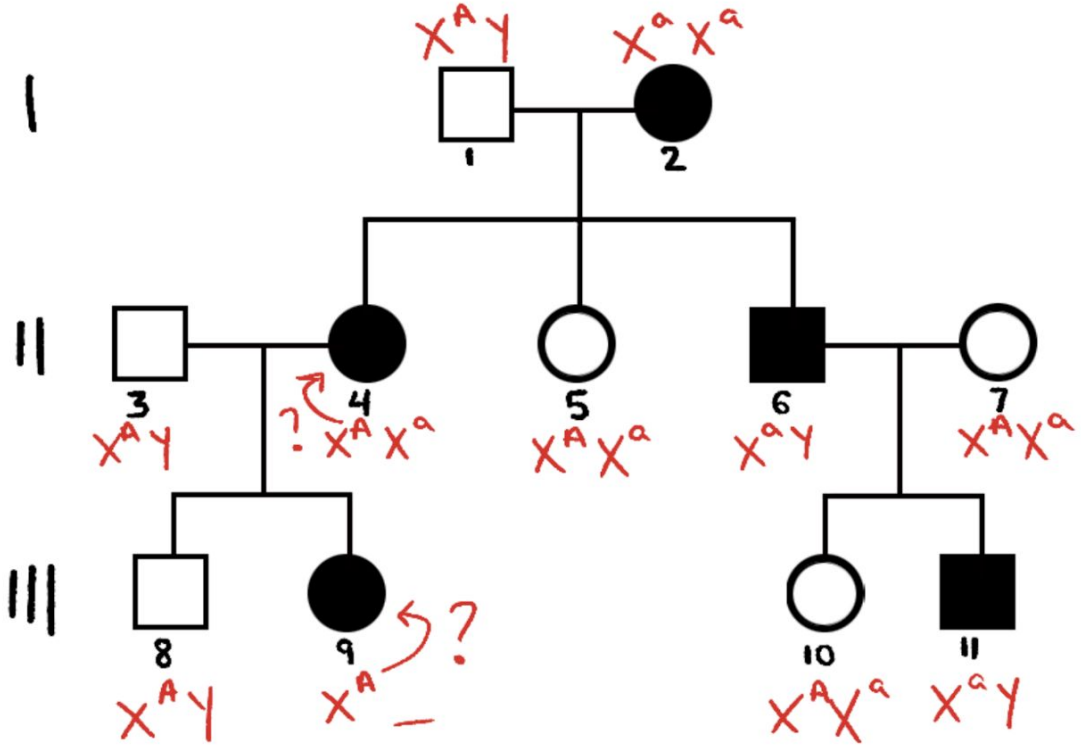
X-Linked Recessive?



X^a = affected

X^A = unaffected

X-Linked Recessive? IMPOSSIBLE

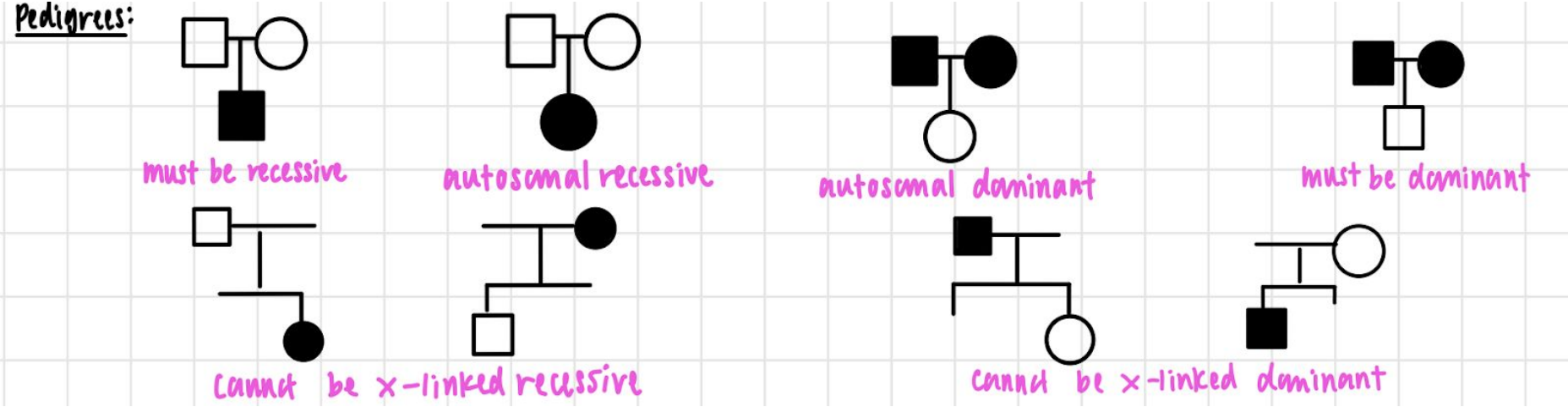


X^a = affected

X^A = unaffected

What should the phenotypes of ind. 4 and 9 be if this mode of inheritance were correct?

Cheatsheet :)


Pedigrees:
must be recessive
autosomal recessive
autosomal dominant
must be dominant
cannot be x-linked recessive
cannot be x-linked dominant

Modes of Inheritance - Pedigree review

- Sons inherit their X-chromosome from their mother, daughters get one from both parents

Impossible IF:

- Autosomal Dominant: affected child with 2 unaffected parents
- Autosomal recessive: unaffected child with 2 affected parents
- X-linked dominant: unaffected mother with affected son
- X-linked recessive: unaffected father with affected daughter

Typical:

- Autosomal Dominant: affected parents with a mix of affected and unaffected children
- Autosomal recessive: affected children of unaffected parents
- X-linked dominant: affected fathers, unaffected mothers with affected daughters
- X-linked recessive: affected mothers with affected sons

Final Comments

Good luck on the midterm!!! If you need more help, make sure to check the extra office hours Lynn will be holding - see the class slides for more info :)

Some tips:

- Don’t use these slides as a be-all-end-all! Make sure to review class notes and learning objectives
- Try to practice writing in a test environment - set time limits when doing practice midterms and mark yourself afterwards
- Come up with variations on worksheet problems
- Learn from your mistakes!!! Make a sheet of what you’ve done wrong on practice midterms, and come up with ways to prevent those mistakes
- Breathe :) This is the first midterm, and it is not the end of the world if you don’t do as well as you’d like


YOU GOT THIS!