Chapter 11 - Genetics

Essential Question:

How are traits passed from one generation to the next?

Objectives:

- *Describe the relationship between the terms genetics, traits, genes and alleles*
- *Distinguish heterozygous and homozygous genotypes*
- *Explain the relationship between phenotype and genotype*

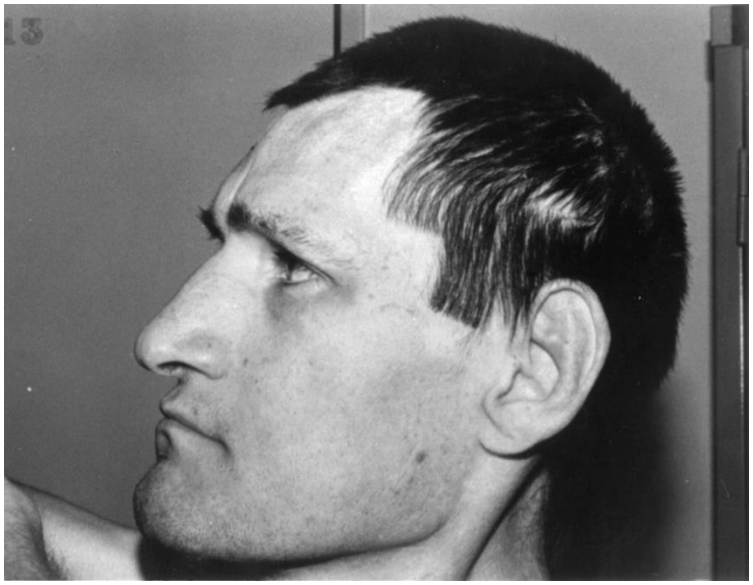
Ehlers-Danlos Syndrome

Hitchhiker's Thumb

NOT Hitchhiker's Thumb

Roman Nose

Straight Nose



Some basic definitions

- Heredity –

- Genetics –

Some more definitions

- Gene –
- Allele –
  - Dominant allele –
  - Recessive allele –

Chapter 11 - Genetics

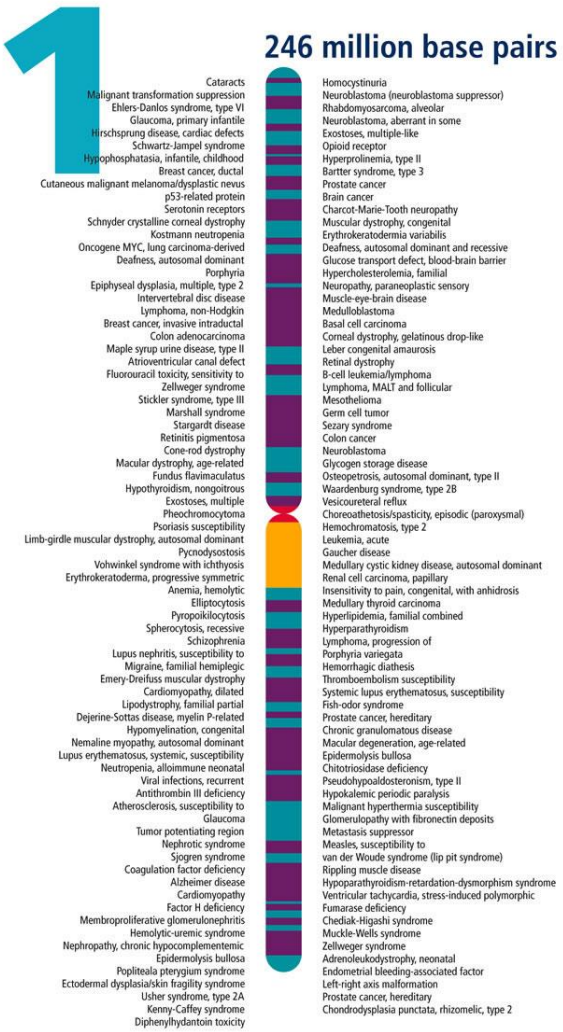
Essential Question:

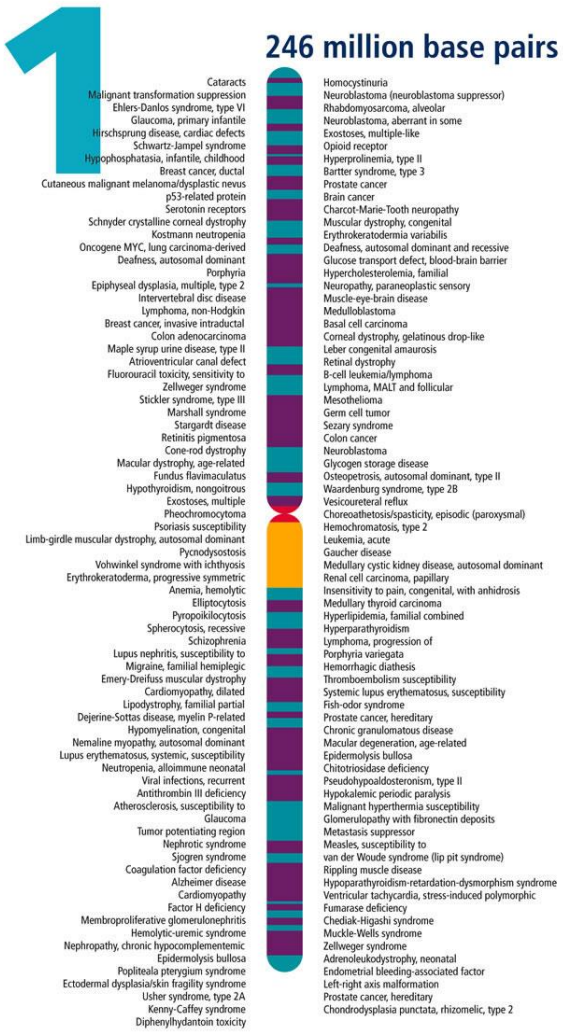
How are traits passed from one generation to the next?

Objectives:

- *explain how probability can be used to predict genetic outcomes*
- *use a Punnett square to predict expected genetic outcomes*

Each Chromosome has many Genes

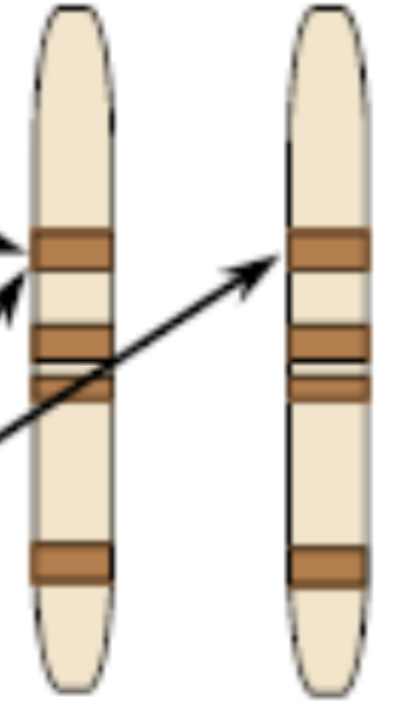


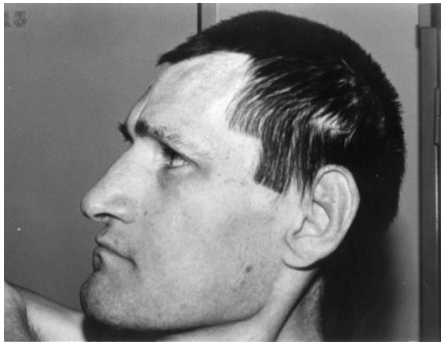


Chromosomes, Genes and Alleles - Make the Connection

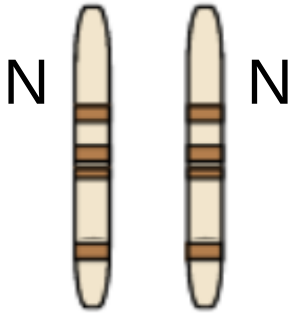
Genes:

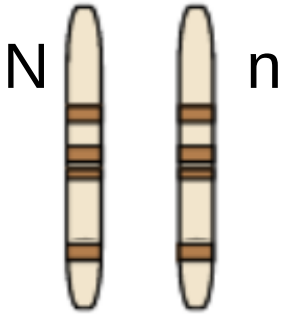
Alleles:

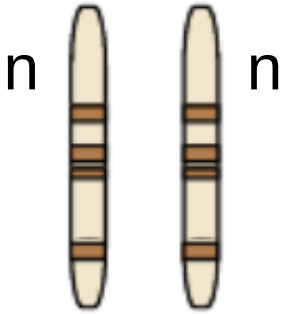




Genotypes and Phenotypes







Gene (Trait)

	Genotype	Phenotype
Homozygous dominant		
Heterozygous		
Homozygous recessive		

Dominant allele

Recessive allele

Punnett Squares

- Tool

  To determine the expected outcome of a genetic cross

- What do they show?

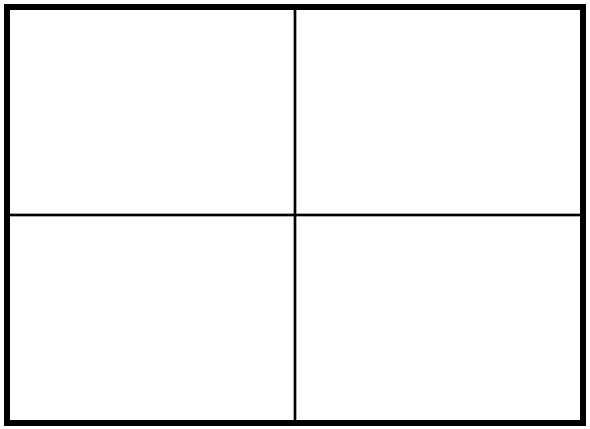
Punnett squares show segregation (meiosis) and recombination (fertilization) of alleles

  – Does this mean it will always be this way?

Punnett Squares

Gene (Trait) Dominant allele Recessive allele

Problem:
A plant that is heterozygous for tall is crossed with another heterozygous tall plant. What is the ratio of tall to short plants resulting from this cross?



Genotype and Phenotype Ratios

Gene (Trait)	Dominant allele	Recessive allele
Plant height	Tall (T)	Short (t)

Problem:
A plant that is heterozygous for tall is crossed with another heterozygous tall plant. What is the ratio of tall to short plants resulting from this cross?

	T	t
T	TT	Tt
t	Tt	tt

phenotype ratio – 3:1 tall:short
genotype ratio – 1:2:1
homozygous : heterozygous: homozygous
dominant recessive

Try some on your own

Chapter 11 - Genetics

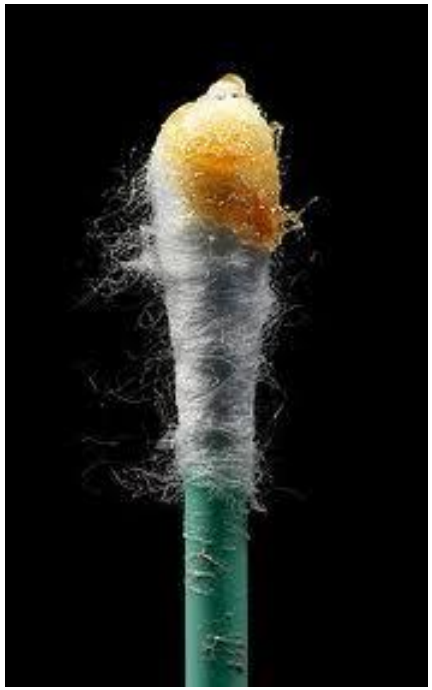
Essential Question:

How are traits passed from one generation to the next?

Objectives:

- *explain what is meant by independent assortment*
- *use a Punnett square to predict the outcome of a two factor cross*

Gene: Ear Wax
Alleles: Wet or dry



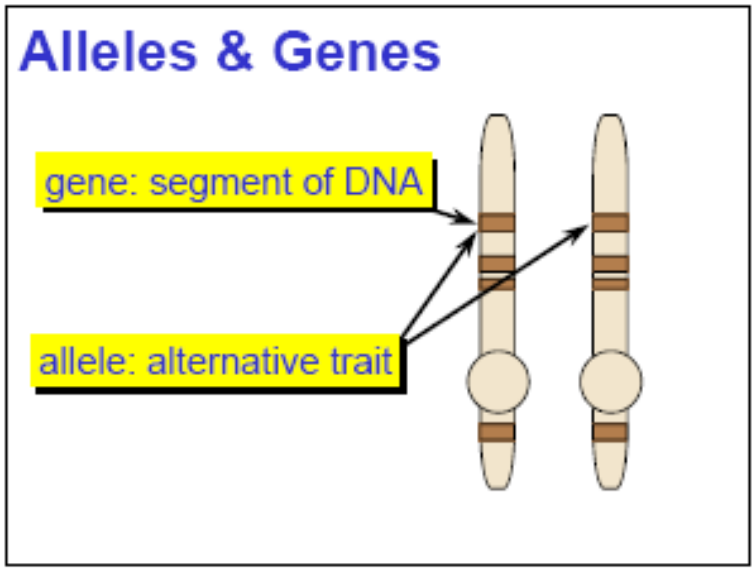
ABCC11
Chromosome 16

Gene: Smell Receptor
Alleles: Smell or not

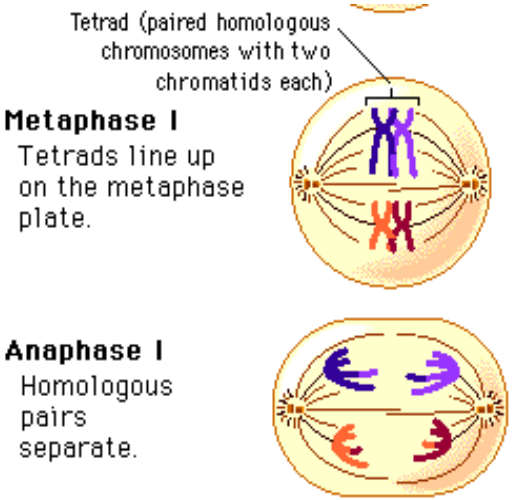
Rs4481887
Chromosome 1

Mendel's First - Law of Segregation

- Mendel's first law of genetics
- The two members of a gene pair segregate randomly and equally into the gametes, which then combine at random to form the next generation.

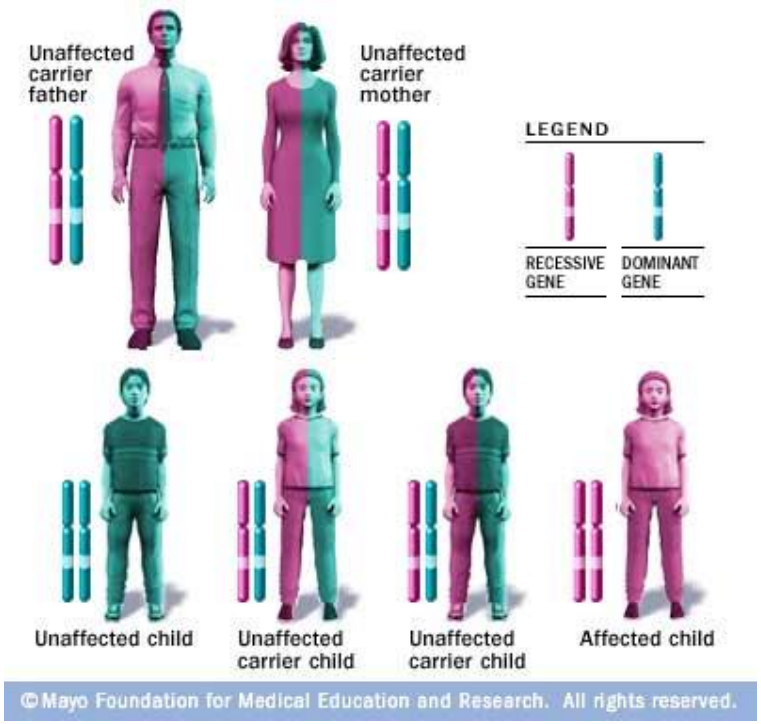


When does this occur?

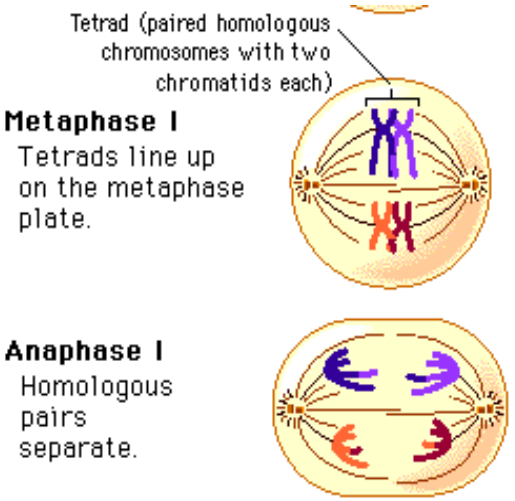


Meiosis I
Homologous chromosomes separate

Law of Segregation



When does this occur?

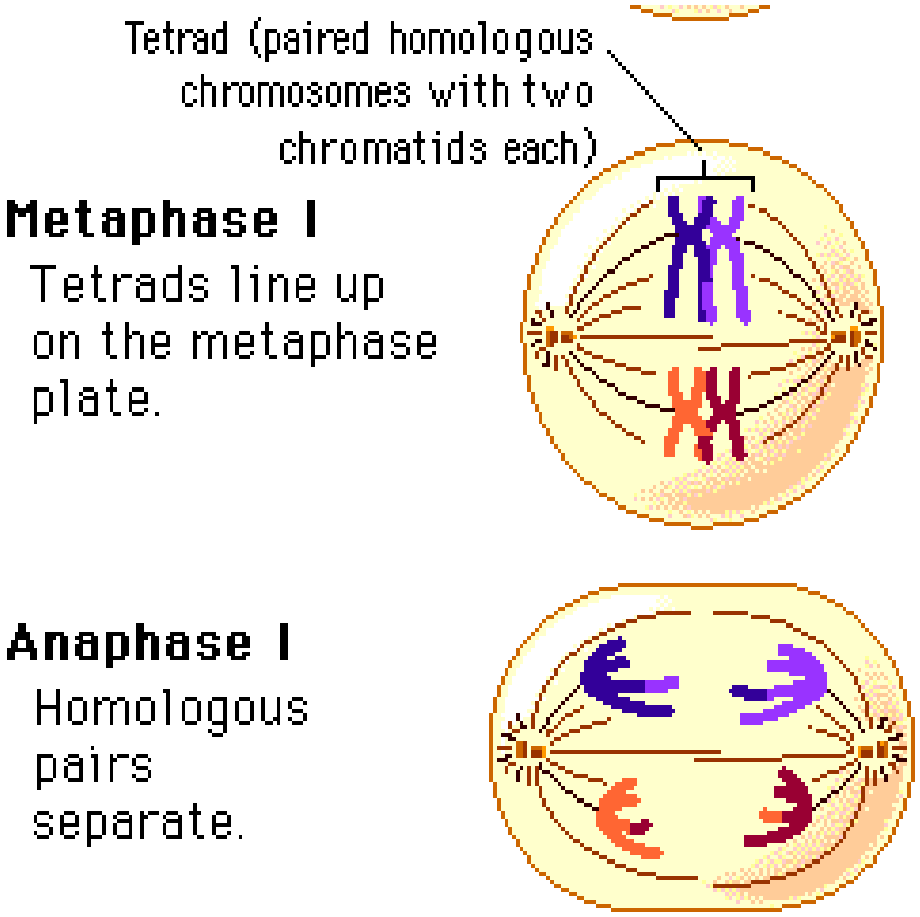


Meiosis I
Homologous chromosomes separate

Mendel's Second - Law of Independent Assortment

- Alleles for different traits can segregate into gametes randomly and independently of each other.
- Ex. Just because you have wet ear wax doesn't mean you can smell asparagus in urine.
  - They are inherited INDEPENDENTLY!
  - Because they are on different chromosomes

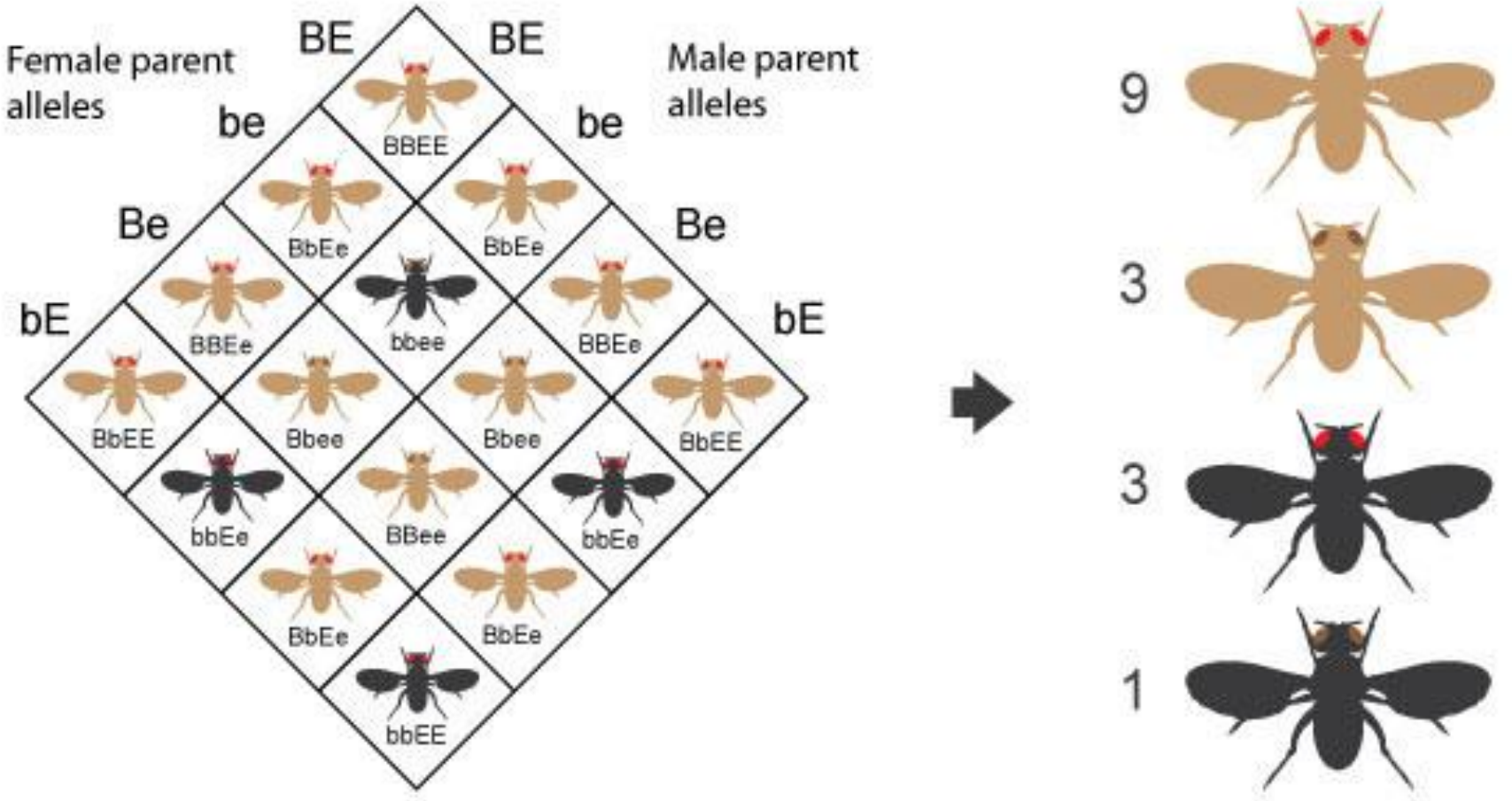
Law of Independent Assortment



During Meiosis I

- Homologous chromosomes distribute randomly on either side of the metaphase plate.
- Each chromosome will sort independently of each other

Two Factor (gene) Crosses



Crossing of 2 traits –Dihybrid Cross

Black fur = B, Brown Fur = b

Short fur = F, Long fur = f

A guinea pig heterozygous for both traits would be BbFf

Yes… Yes, it is a guinea pig in a dinosaur suit.

What are the genes (traits)?

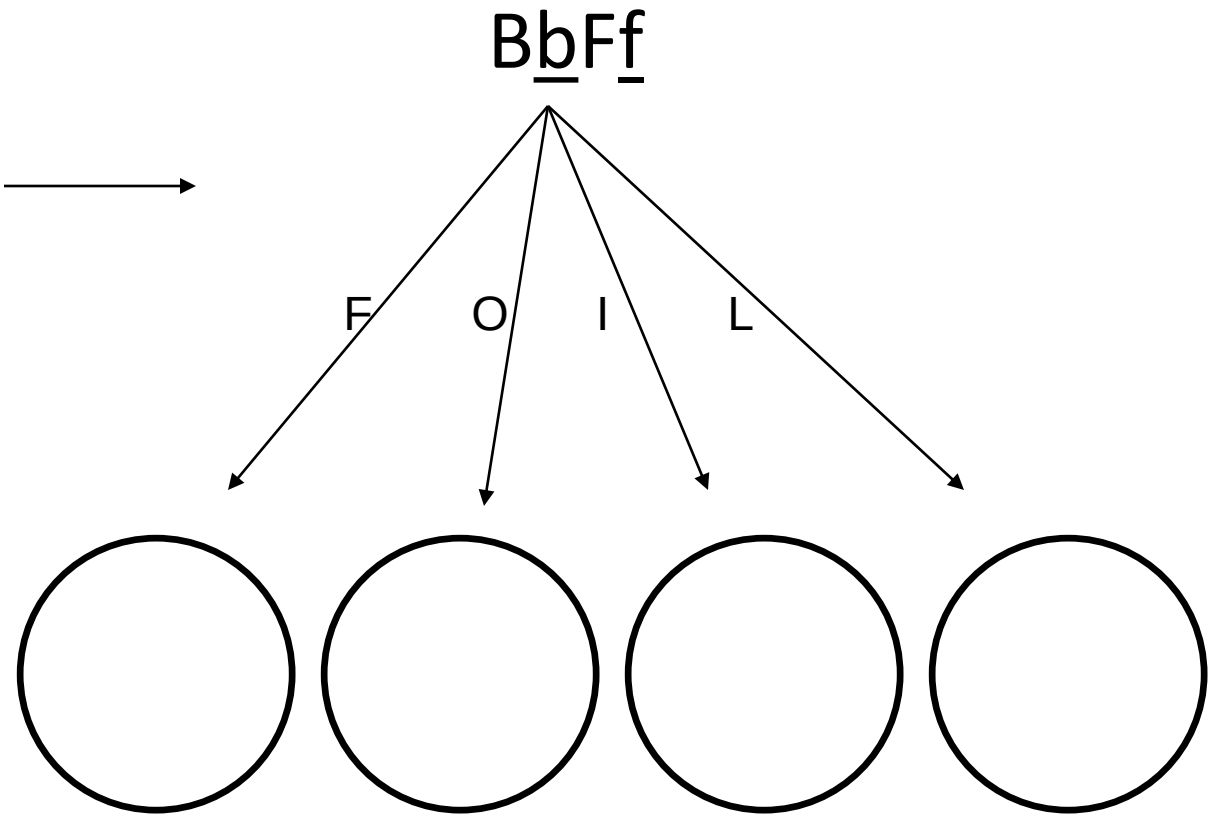
Genotypes for each trait?

Phenotypes for each trait?

Genotype of gametes from a BbFf individual?

What are the gametes from BbFf?

FOIL method →
First
Outer
Inner
Last



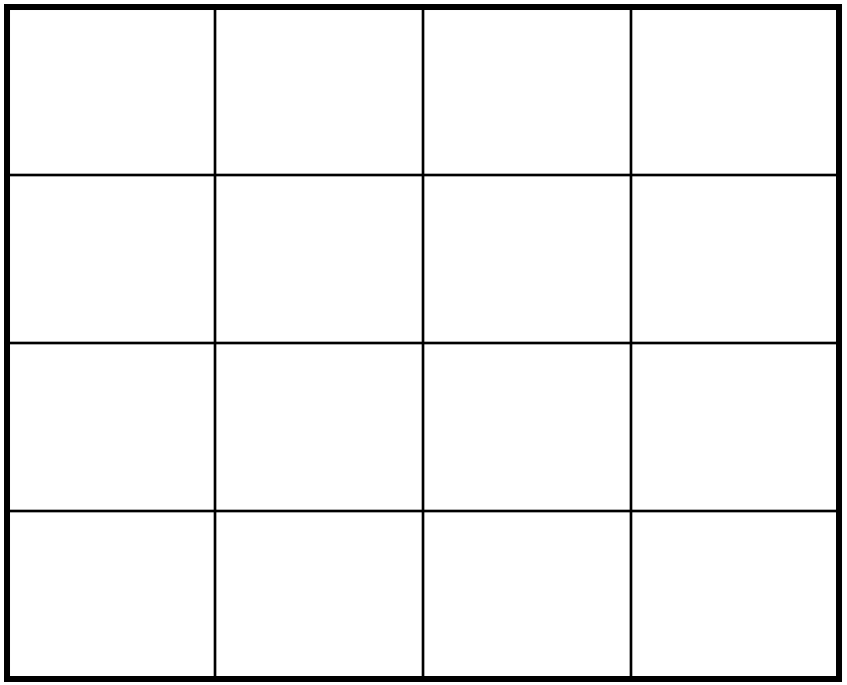
Punnett Square for a Dihybrid Cross

Parent 1 B<u>b</u>F<u>f</u> x Parent 2 B<u>b</u>F<u>f</u>

Use FOIL
to determine
the gametes

B<u>b</u>F<u>f</u>

B<u>b</u>F<u>f</u>



Punnett Square for a Dihybrid Cross

Write this on the side of your Punnett Square for the Dihybrid Cross

Phenotypes % Occurrence

= both dominant traits
= one dominant and one recessive trait
(fur length) (fur color)
= one recessive and one dominant trait
(fur length) (fur color)
= both recessive traits

Punnett Square – Dihybrid Cross

BbFf x BbFf

Black fur = B
Brown fur = b

Short fur = F
Long fur = f

Phenotypes

9 = both dominant traits
3 = one recessive trait (fur color)
3 = one recessive trait (fur length)
1 = both recessive

	BF	Bf	bF	bf
BF	BBFF	BBFf	BbFF	BbFf
Bf	BBFf	BBff long	BbFf	Bbff long
bF	BbFF	BbFf	bbFF	bbFf
bf	BbFf	Bbff long	bbFf	bbff long

Dihybrid Crosses – Alternate Method

- Dihybrid cross can be constructed and analyzed by looking at each gene individually. L<u>l</u>P<u>p</u> x L<u>l</u>P<u>p</u>

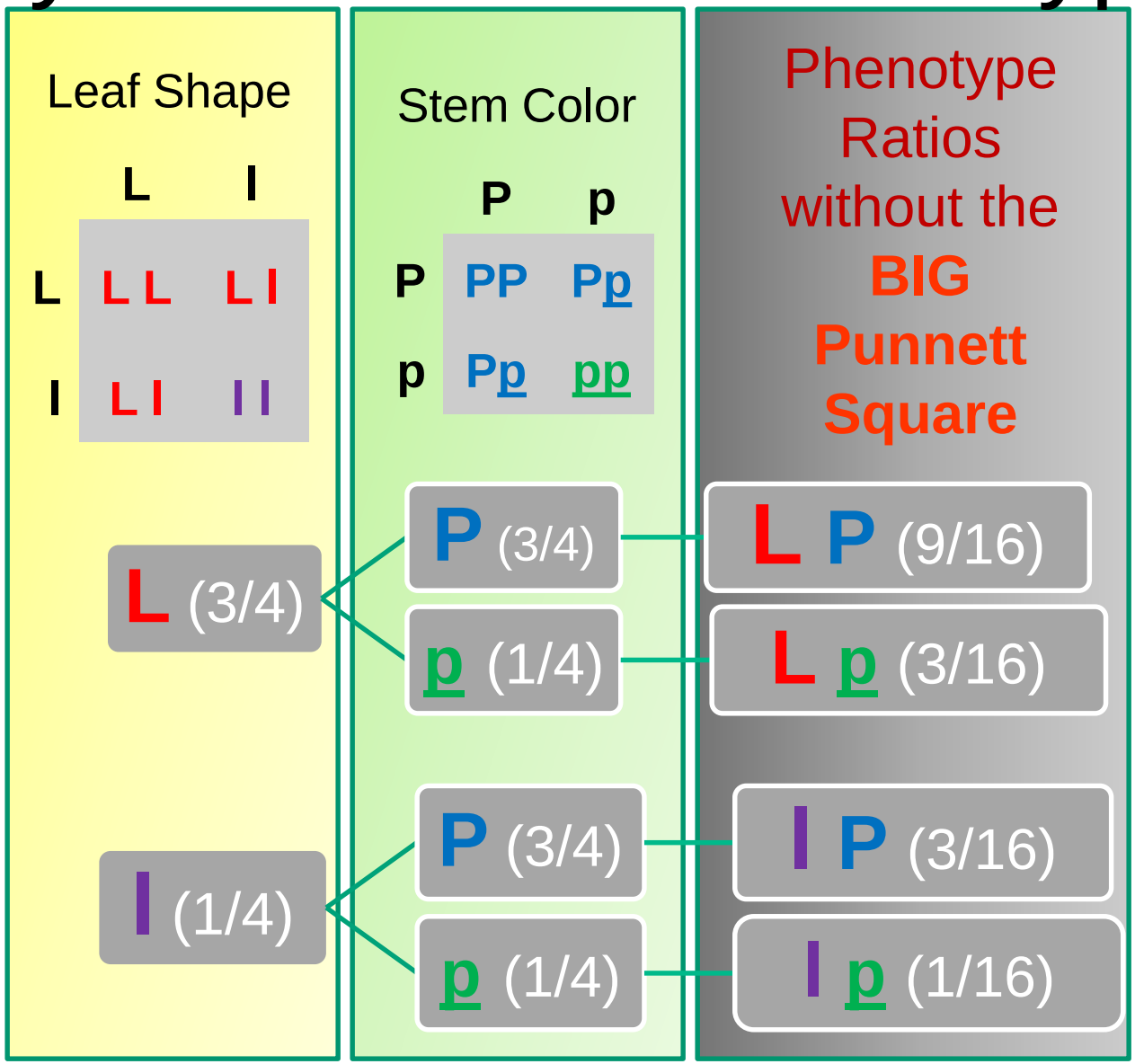
Leaf Shape

	L	**<u>l</u>**
L	**L L**	**L <u>l</u>**
<u>l</u>	**L <u>l</u>**	**<u>l l</u>**

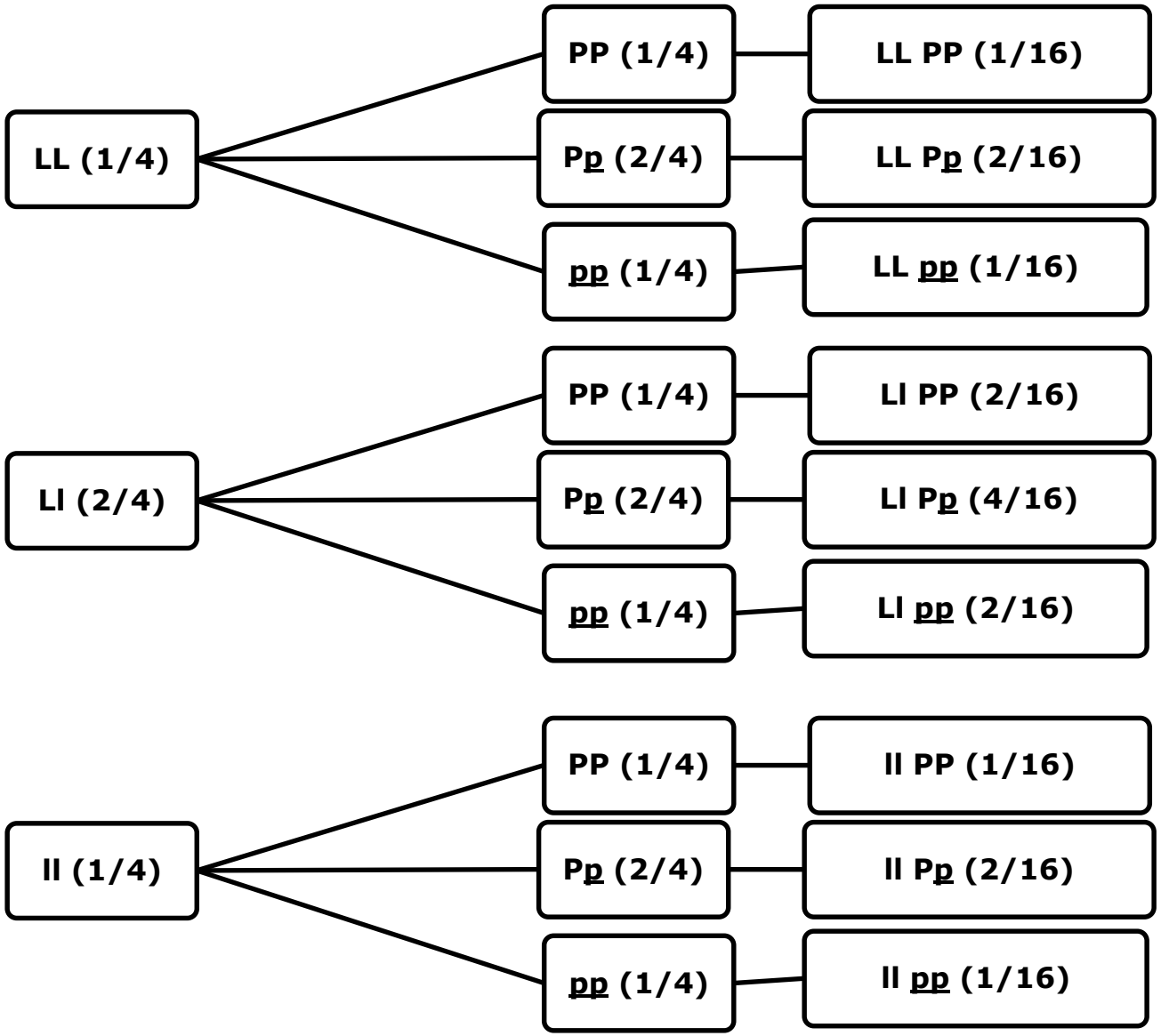
Stem Color

	P	**<u>p</u>**
P	**P P**	**P <u>p</u>**
<u>p</u>	**P <u>p</u>**	**<u>p p</u>**

Dihybrid Math for Phenotype



Dihybrid Math for Genotype



Parents
LlPp x LlPp

Leaf Shape

	L	l
L	L L	L l
l	L l	l l

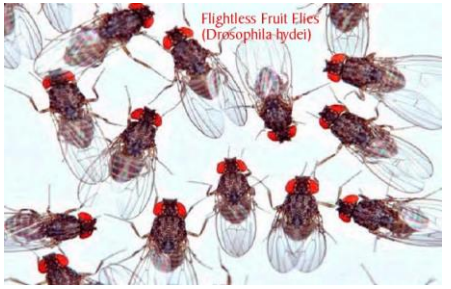
Stem Color

	P	p
P	PP	Pp
p	Pp	pp

Two Factor Crosses

In ***fruit flies***, wings are dominant over no wings. Red eyes are dominant over yellow eyes.

If a homozygous dominant, winged fly with heterozygous eyes is crossed to another fly with no wings and yellow eyes:



- what are the genes (traits)?
- what are the alleles for each trait.
- identify the genotype of each parent.
- what are all the possible gametes of each parents?
- what is the probability of getting a winged fly with yellow eyes in the offspring?

Chapter 11 - Genetics

Essential Question:

How are traits passed from one generation to the next?

Objectives:

- *describe four patterns of inheritance that do not follow the rules of simple dominance*

Now what?

- So far we have talked about genetics patterns with simple dominance and recessive patterns of inheritance
- What happens when it isn’t quite so easy?

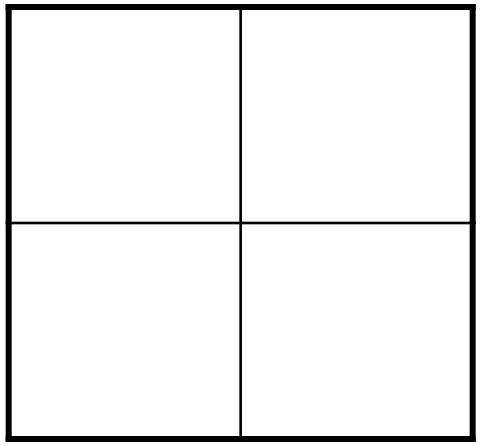
Incomplete Dominance

- Dominant and recessive alleles exist, however…
  - Both alleles contribute to the phenotype
  - The heterozygous genotype shows a blending of alleles
  - 3 genotypes result in 3 phenotypes

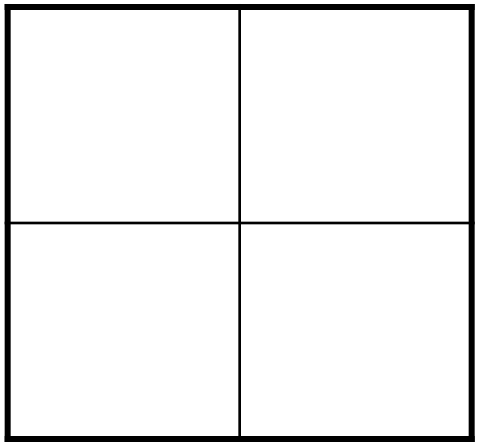
Incomplete Dominance

In Japanese Four-O-Clocks, the gene controlling flower color has alleles that are neither dominant nor recessive. Plants that have two red alleles (RR) have red flowers. Plants with two white alleles (WW) are white. BUT, plants with one red allele and one white allele (RW) are pink.

Cross a red flowered plant and a white flowered plant.



Cross two pink flowering plants.



Incomplete Dominance

In some cats, the gene for tail length shows incomplete dominance. Cats can have no tails (NN), long tails (LL), or short tails (NL).

Cross a short tail cat and a cat with no tail.

Cross a long tail cat and a short tail cat. What proportion of the offspring will have short tails? Long tails?

Codominance

- No recessive allele
- Both alleles are dominant and show up in the phenotype
- Different from incomplete dominance because there is NO BLENDING of traits

Codominance

In Erminette chickens, the gene for feather color has two codominant alleles – one for black feathers (F^BF^B) and one for white feathers (F^WF^W). Heterozygous chickens (F^BF^W) have BOTH black and white feathers, resulting in a distinctive speckled pattern.

Cross a white chicken and a black chicken.

Cross a black chicken and a speckled chicken.

Codominance

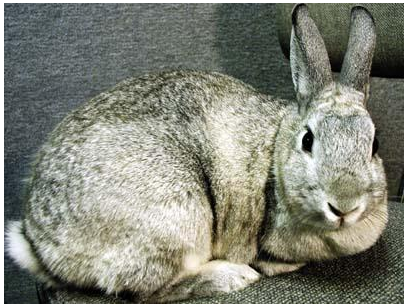


In cows, the allele for red hair (H^R) and the allele for white hair (H^W) are codominant. The Heterozygous condition results in a mixture of red and white hairs and the cows are called roan.

Cross a red cow with a white bull. What is the genotype and phenotype ratio of the offspring?

Multiple Alleles

- Rather than two alleles, there maybe 3, 4 or more.
- A hierarchy exists as to which allele is dominant in an individual
- Example: $C > c^{ch} > c^{h} > \underline{c}$

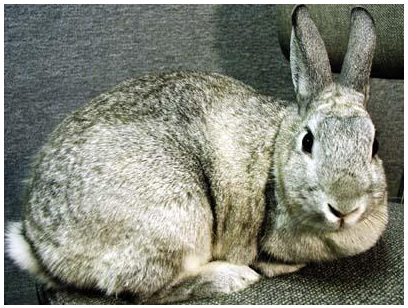




Multiple Alleles

Full color

C

>



Chinchila

c^{ch}

>

Himalayan

c^{h}

>

Albino

$\underline{c}$

What is the genotype(s) of an albino?

What is the genotype(s) of a Himalayan?

What is the genotype(s) of a full color?

Multiple Alleles

Full color

C

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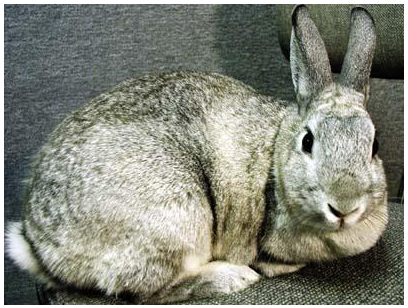


Chinchila

c^{ch}

>

Himalayan

c^{h}

>

Albino

$\underline{c}$

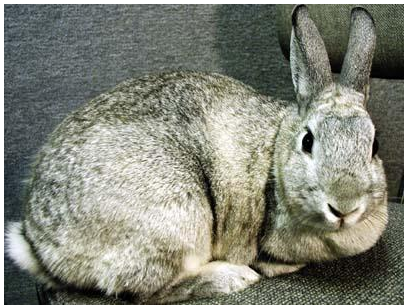
A full color rabbit has an unknown genotype. How could you determine the genotype using a testcross breeding experiment?

Multiple Alleles

Full color

C

>



Chinchila

c^{ch}

>

Himalayan

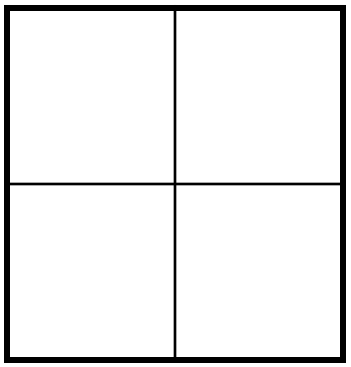
c^{h}

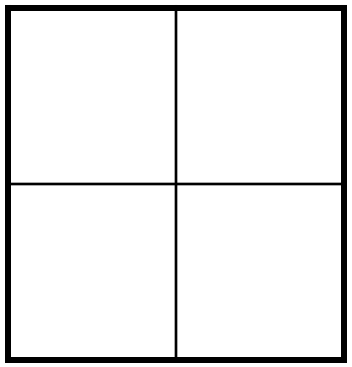
>

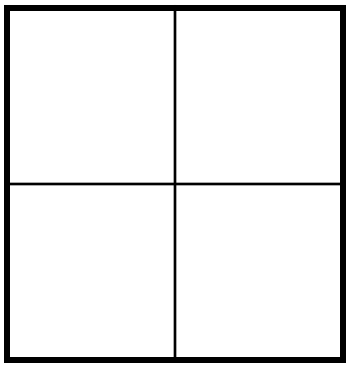
Albino

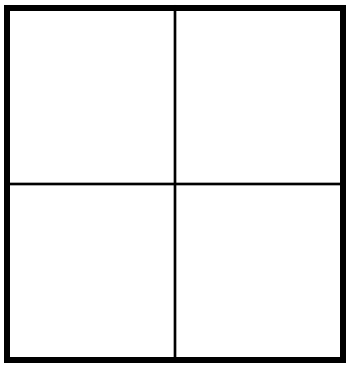
$\underline{c}$

What are the potential outcomes from this test cross?







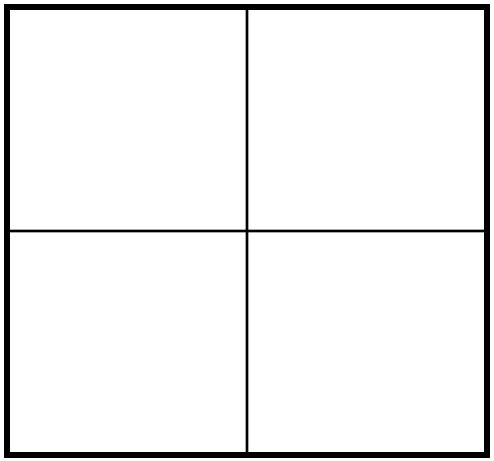


Multiple Alleles

Full color		Chinchila		Himalayan		Albino
C	>	c^{ch}	>	c^{h}	>	$\underline{c}$

A friend gives you a litter of baby rabbits. Since the babies represent the results of a single mating, what are the ***probable*** genotypes of the two parents? Show a Punnett Square to support your answer, there may be more than one correct answer. *A good starting point would be to fill in the squares of a Punnett Square with possible offspring and then determine the parental genotypes.*

The litter contains 6 Full Color, 3 Himalayan, and 3 Albino

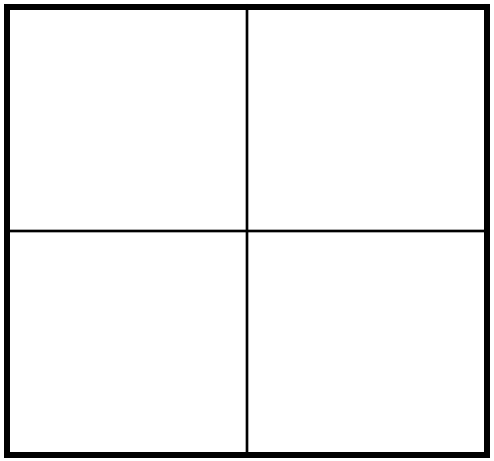


Multiple Alleles

Full color		Chinchila		Himalayan		Albino
C	>	c^{ch}	>	c^{h}	>	$\underline{c}$

A friend gives you a litter of baby rabbits. Since the babies represent the results of a single mating, what are the ***probable*** genotypes of the two parents? Show a Punnett Square to support your answer, there may be more than one correct answer. *A good starting point would be to fill in the squares of a Punnett Square with possible offspring and then determine the parental genotypes.*

The litter contains 6 Chinchilla and 2 Himalayan



Eye color is Polygenic

- Multiple genes contribute to eye color.
- HERC2 and OCA2 are major genes (chromosome 15)
- Many others contribute

In a dihybrid cross, AaBb x AaBb, what fraction of the offspring will be homozygous for both recessive traits? What fraction will be homozygous dominant for both traits? What fraction will be heterozygous for both traits?

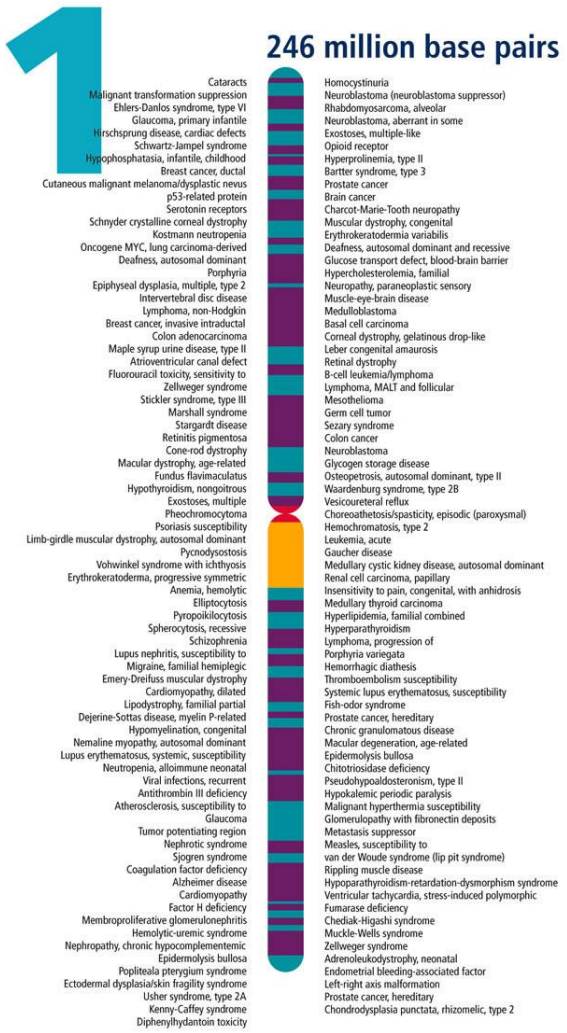
Use either a Punnett square or math to show how you got your answer.

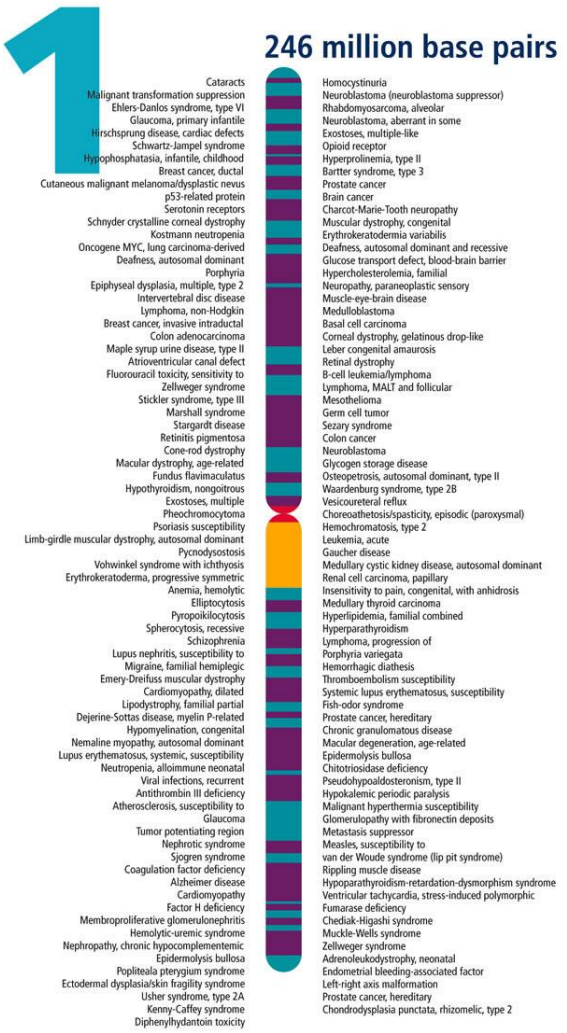
In fruit flies, the allele for black body color is dominant over the allele for brown body color. Straight wings is dominant over curled wings. Imagine that a black bodied, straight-winged fly that is heterozygous for both characteristics is mated with a fly with brown body color and curled wings.

1. Identify the genes and their alleles.
2. Identify the genotypes of both parents.
3. Use either a 4x4 Punnett Square or math to predict the phenotype ratios of the offspring. Show all work.

Chapter 11 Section 5
Linkage and Gene Mapping

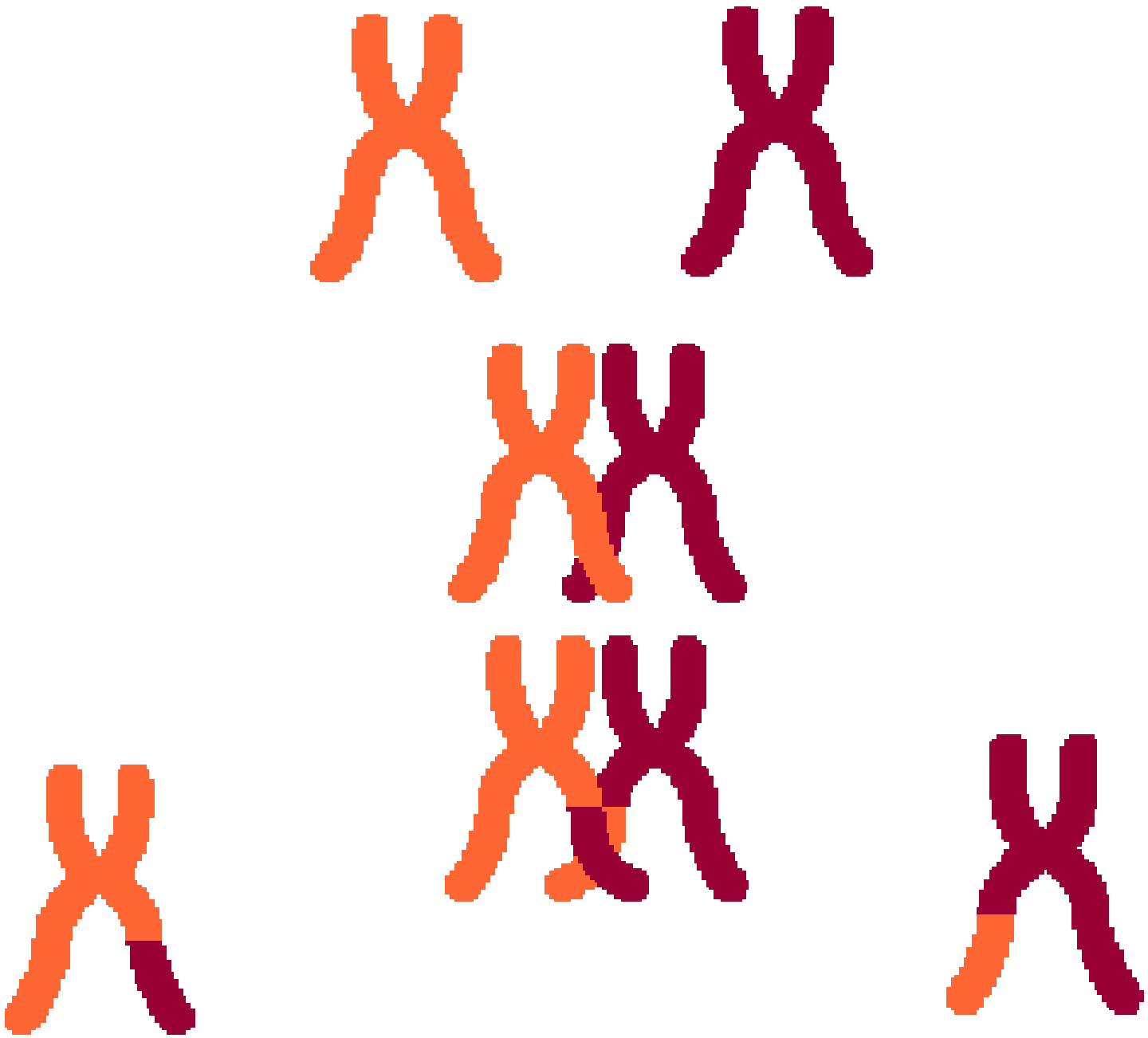
Each Chromosome has many Genes





Gene Linkage

- Chromosomes can have 100's of genes on them
- Genes that occur on the same chromosome are said to be LINKED GENES because they are usually inherited together.
- Linked genes DO NOT segregate independently of one another during meiosis.
- However, there is a time when genes on the same chromosome are not inherited together. When?



Gene Mapping

- The frequency of recombination between two points on a chromosome varies directly with the distance between the two points.

  % frequency = # of map units apart

- The farther apart two genes are, the more likely they are to be exchanged during crossing over

  higher % frequency = Greater Map Units Apart

- The closer they are the less likely that crossing over will separate them.

  lower % frequency = Fewer Map Units Apart

Making a gene map

- Question: (Pg. 285)
  - Genes A, B, C and D are located on the same chromosome.
  - After calculating recombination frequencies, a student determines that these genes are separated by the following map units:
    - C-D: 25 Map Units
    - A-B: 12 Map Units
    - B-D: 20 Map Units
    - A-C: 17 Map Units

What would the gene map look like for these 4 genes?

Hint: The genes ARE NOT in alphabetical order

Gene map

- C-D: 25 Map Units
- A-B: 12 Map Units
- B-D: 20 Map Units
- A-C: 17 Map Units

Gene map

- C-D: 25 Map Units
- A-B: 12 Map Units
- B-D: 20 Map Units
- A-C: 17 Map Units