# Chapter 11 - Genetics

## **Essential Question:**

How are traits passed from one generation to the next?

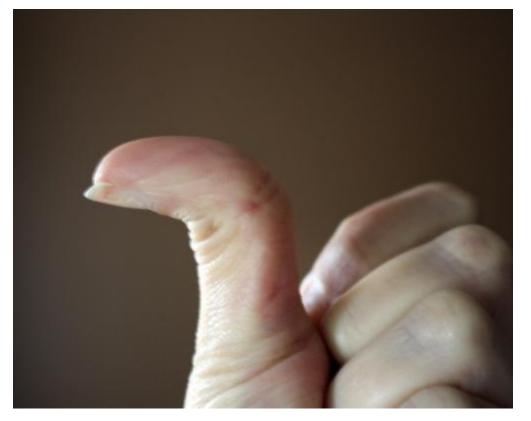
Objectives:

- 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



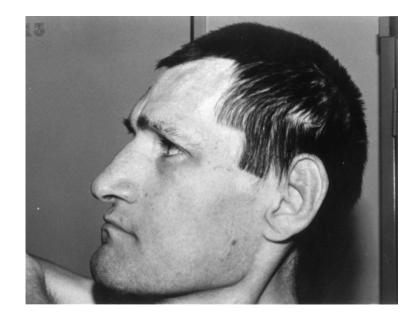
# NOT Hitchhiker's Thumb



## Roman Nose



# Straight Nose



## Some basic definitions

• Heredity –

• Genetics –

## Some more definitions

- Gene –
- Allele –

• Dominant allele –

• Recessive allele –

# Chapter 11 - Genetics

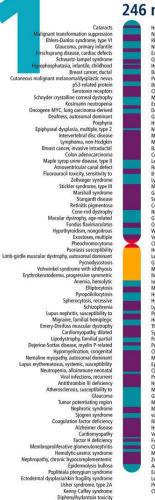
## **Essential Question:**

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



246 million base pairs

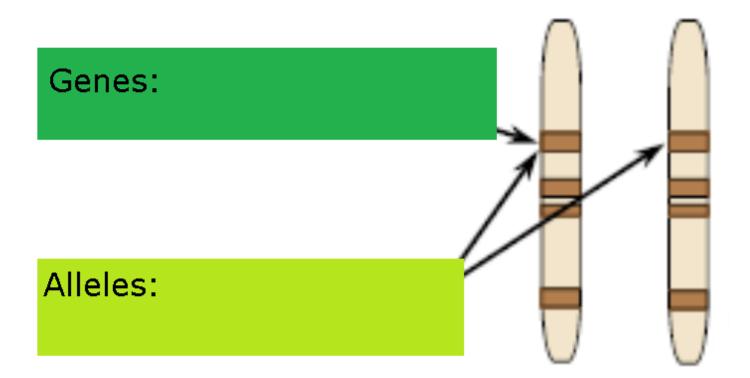
Neurohlastoma (neurohlastoma sunnressor) Rhabdomyosarcoma, alveolar Neuroblastoma, aberrant in some Exostoses, multiple-like Opioid receptor Hyperprolinemia, type II Bartter syndrome, type 3 Prostate cancer Brain cancer Charcot-Marie-Tooth neuropathy Muscular dystrophy, congenital Erythrokeratodermia variabilis Deafness, autosomal dominant and recessive Glucose transport defect, blood-brain barrier Hypercholesterolemia, familial Neuropathy, paraneoplastic sensory Muscle-eye-brain disease Medulloblastoma Basal cell carcinoma Corneal dystrophy, gelatinous drop-like Leber congenital amaurosis Retinal dystrophy B-cell leukemia/lymphoma Lymphoma, MALT and follicular Mesothelioma Germ cell tumor Sezary syndrome Colon cancer Neuroblastoma Glycogen storage disease Osteopetrosis, autosomal dominant, type II Waardenburg syndrome, type 2B Vesicoureteral reflux Choreoathetosis/spasticity, episodic (paroxysmal) Hemochromatosis, type 2 Leukemia, acute Gaucher disease Medullary cystic kidney disease, autosomal dominant Renal cell carcinoma, papillary Insensitivity to pain, congenital, with anhidrosis Medullary thyroid carcinoma Hyperlipidemia, familial combined Hyperparathyroidism Lymphoma, progression of Porphyria variegata Hemorrhagic diathesis Thromboembolism susceptibility Systemic lupus erythematosus, susceptibility Fish-odor syndrome Prostate cancer, hereditary Chronic granulomatous disease Macular degeneration, age-related Epidermolysis bullosa Chitotriosidase deficiency Pseudohypoaldosteronism, type II Hypokalemic periodic paralysis Malignant hyperthermia susceptibility Glomerulopathy with fibronectin deposits Metastasis suppresso Measles, susceptibility to van der Woude syndrome (lip pit syndrome) Rippling muscle disease Hypoparathyroidism-retardation-dysmorphism syndrome Ventricular tachycardia, stress-induced polymorphic Fumarase deficiency Chediak-Higashi syndrome Muckle-Wells syndrome Zellweger syndrome Adrenoleukodystrophy neonatal Endometrial bleeding-associated factor Left-right axis malformation Prostate cancer, hereditary Chondrodysplasia punctata, rhizomelic, type 2

Cataracts Malignant transformation suppression Ehlers-Danlos syndrome, type VI Glaucoma, primary infantile rschsnrung disease cardiac defects Schwartz-Jampel syndrome ophosphatasia, infantile, childhood Breast cancer, ductal Cutaneous malignant melanoma/dysplastic nevus p53-related protein Serotonin receptors Schnyder crystalline corneal dystrophy Kostmann neutropenia Oncogene MYC, lung carcinoma-derived Deafness, autosomal dominant Pomhyria Epiphyseal dysplasia, multiple, type 2 Intervertebral disc disease Lymphoma, non-Hodgkin Breast cancer, invasive intraductal Colon adenocarcinoma Maple syrup urine disease, type II Atrioventricular canal defect Fluorouracil toxicity, sensitivity to Zellweger syndrome Stickler syndrome, type III Marshall syndrome Stargardt disease Retinitis pigmentosa Cone-rod dystrophy Macular dystrophy, age-related Fundus flavimaculatus Hypothyroidism, nongoitrous Exostoses, multiple Pheochromocytoma Psoriasis susceptibility Limb-girdle muscular dystrophy, autosomal dominant Pycnodysostosis Vohwinkel syndrome with ichthyosis Erythrokeratoderma, progressive symmetric Anomia homolytic Elliptocytosis Pyropoikilocytosis Spherocytosis, recessive Schizophrenia Lupus nephritis, susceptibility to Migraine, familial hemiplegic Emery-Dreifuss muscular dystrophy Cardiomyopathy, dilated Lipodystrophy, familial partial Dejerine-Sottas disease, myelin P-related Hypomyelination, congenital Nemaline myopathy, autosomal dominant Lupus erythematosus, systemic, susceptibility Neutropenia, alloimmune neonatal Viral infections, recurrent Antithrombin III deficiency Atherosclerosis, susceptibility to Glaucoma Tumor potentiating region Nephrotic syndrome Sjogren syndrome Coagulation factor deficiency Alzheimer disease Cardiomyopathy Factor H deficiency Membroproliferative glomerulonephritis Hemolytic-uremic syndrome Nephropathy, chronic hypocomplementemic Epidermolysis bullosa Popliteala pterygium syndrome Ectodermal dysplasia/skin fragility syndrome Usher syndrome, type 2A Kenny-Caffey syndrome Diphenylhydantoin toxicity

#### 246 million base pairs

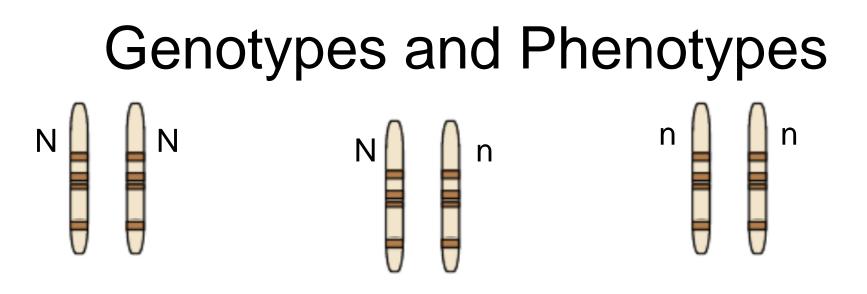
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## Chromosomes, Genes and Alleles -Make the Connection









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

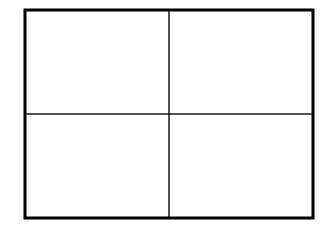
- Does this mean it will always be this way?

# **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?

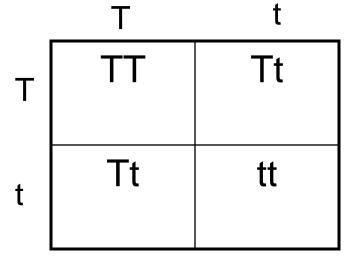


# Genotype and Phenotype Ratios

<u>Gene (Trait)</u> Plant height Dominant allele Tall (T) <u>Recessive allele</u> 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?



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

## Try some on your own

# Chapter 11 - Genetics

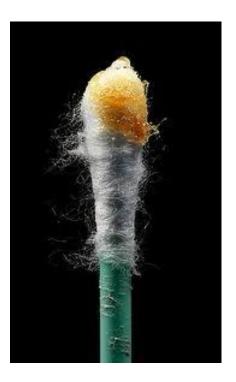
## **Essential Question:**

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



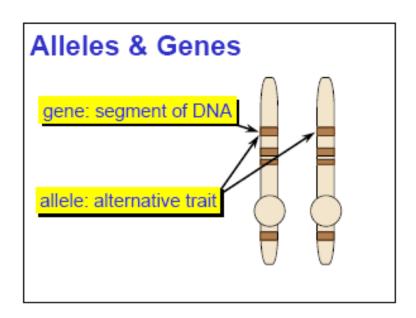
Gene: Smell Receptor Alleles: Smell or not



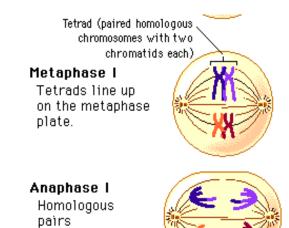
ABCC11 Chromosome 16 Rs4481887 Chromosome 1

## 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.



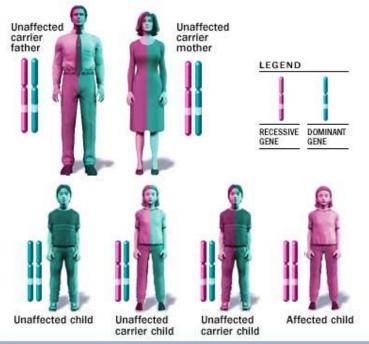
## When does this occur?



separate.

Meiosis I Homologous chromosomes separate

## Law of Segregation



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## When does this occur?

Tetrad (paired homologous chromosomes with two chromatids each)

#### Metaphase I

Tetrads line up on the metaphase plate.

Anaphase I Homologous pairs separate.



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

Tetrad (paired homologous , chromosomes with two chromatids each)

#### Metaphase I

Tetrads line up on the metaphase plate.

# h two each)

#### Anaphase I

Homologous pairs separate.

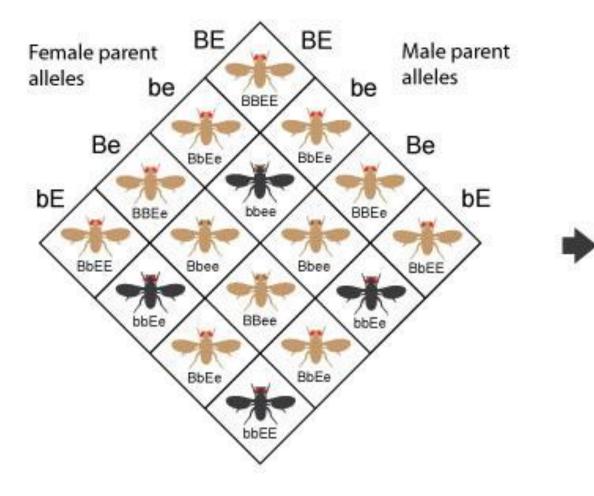


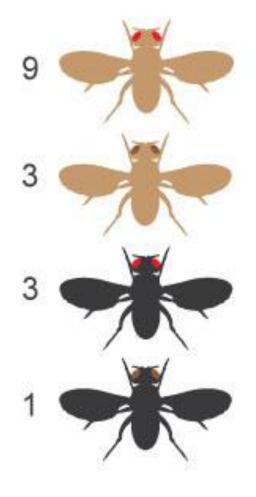
## **During Meiosis I**

•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 =  $\underline{b}$ Short fur = F, Long fur =  $\underline{f}$ 

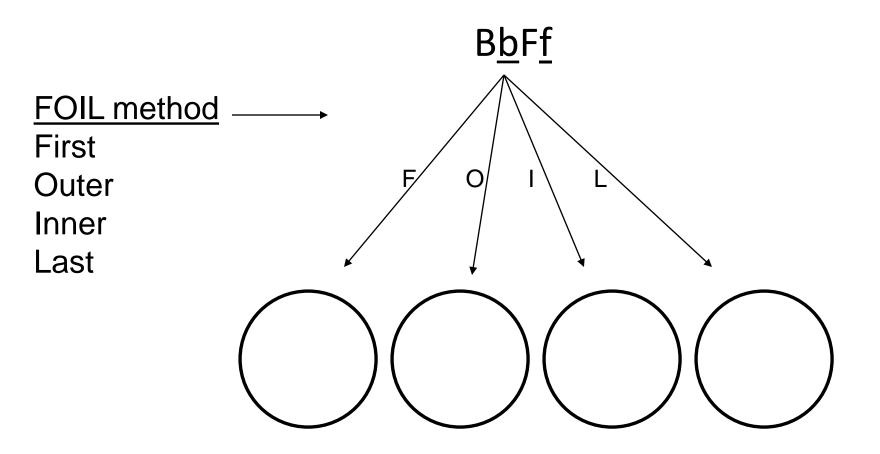
A guinea pig heterozygous for both traits would be B<u>b</u>F<u>f</u>

What are the genes (traits)? Genotypes for each trait? Phenotypes for each trait? Genotype of gametes from a B<u>b</u>F<u>f</u> individual?



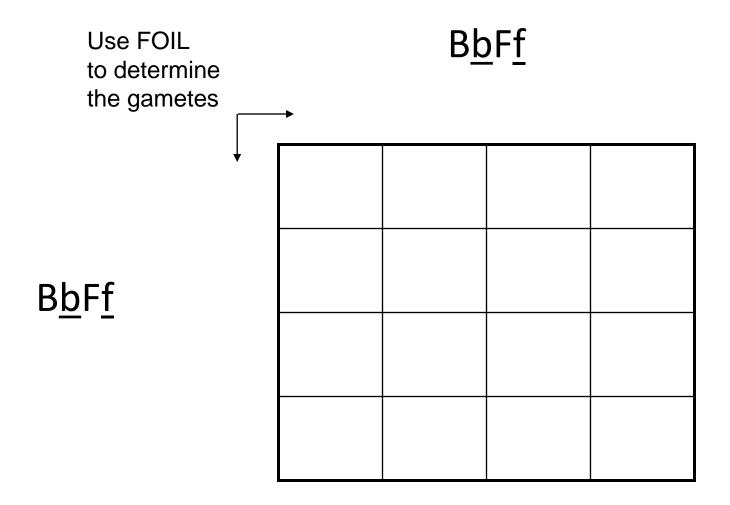
Yes... Yes, it is a guinea pig in a dinosaur suit.

## What are the gametes from B<u>b</u>F<u>f</u>?



## 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>



## 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

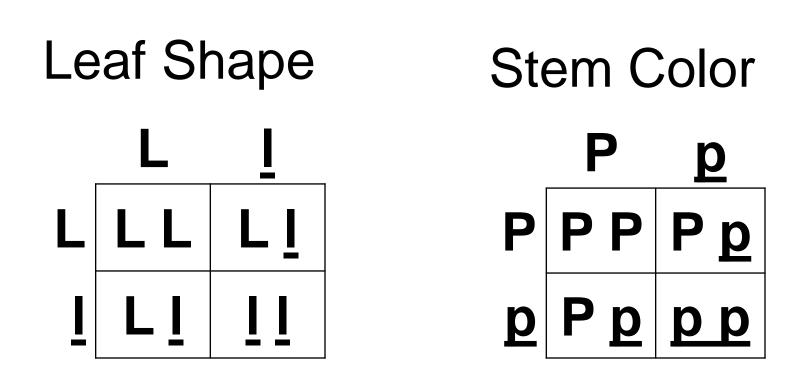
## Punnett Square – Dihybrid Cross

## $B\underline{b}F\underline{f} \times B\underline{b}F\underline{f}$

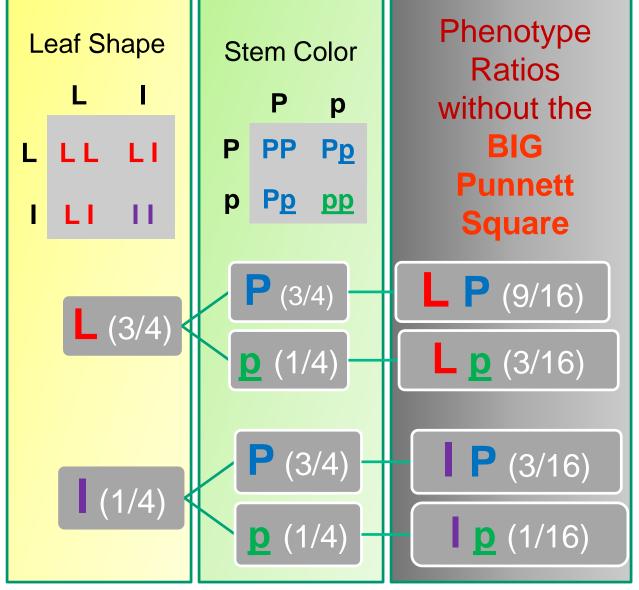
Black fur = B Brown fur = b		BF	B <u>f</u>	<u>b</u> F	bf
Short fur = F Long fur = f	BF	BBFF	BBFf	BbFF	BbFf
<u>Phenotypes</u>	B <u>f</u>	BBFf	BBff long	BbFf	Bbff Iong
<ul> <li>9 = both dominant traits</li> <li>3 = one recessive trait (fur color)</li> </ul>	<u>b</u> F	BbFF	BbFf	bbFF	bbFf
<ul><li>3 = one recessive trait</li><li>(fur length)</li><li>1 = both recessive</li></ul>	<u>bf</u>	BbFf	Bbff long	bbFf	bbff Iong

# Dihybrid Crosses – Alternate Method

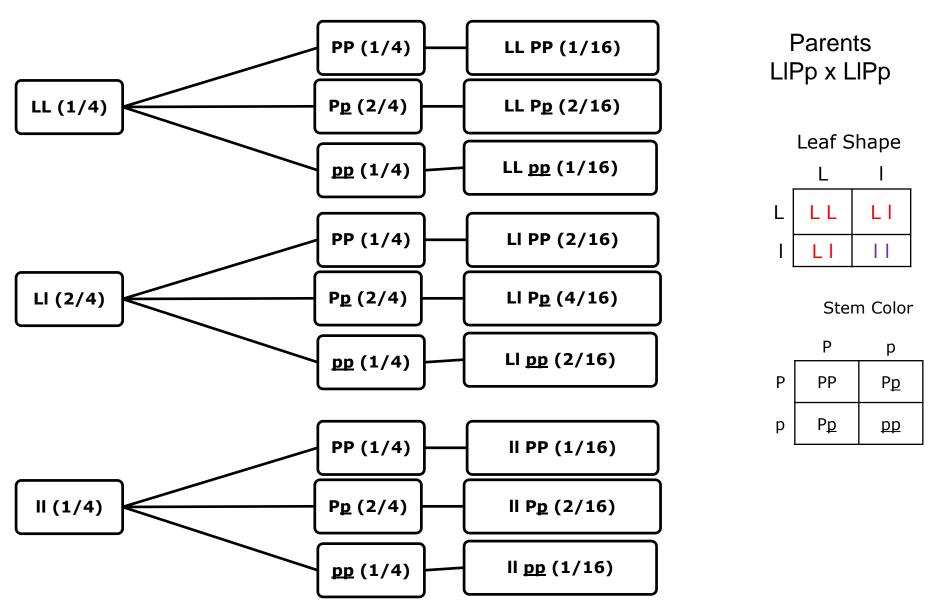
 Dihybrid cross can be constructed and analyzed by looking at each gene individually. LIPp x LIPp



# **Dihybrid Math for Phenotype**



# Dihybrid Math for Genotype



## **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

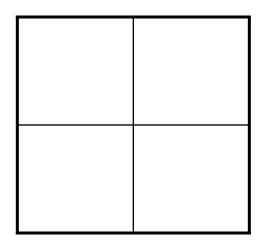


## **Incomplete Dominance**

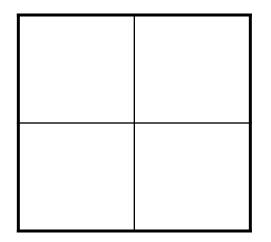
In Japanese Four-O-Clocks, the gene controlling flower color has alleles that are neither dominant nor recessive. Plants that have two red alleles (RR) have red flowers. Plants with two white alleles (WW) are white. BUT, plants with one red allele and one white allele (RW) are pink.



Cross a red flowered plant and a white flowered plant.



Cross two pink flowering plants.



## **Incomplete Dominance**

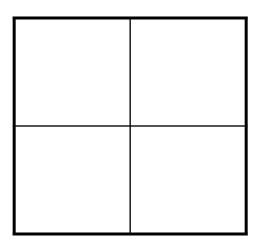
In some cats, the gene for tail length shows incomplete dominance. Cats can have no tails (NN), long tails (LL), or short tails (NL).

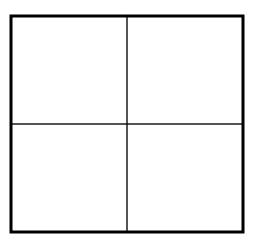




Cross a short tail cat and a cat with no tail.

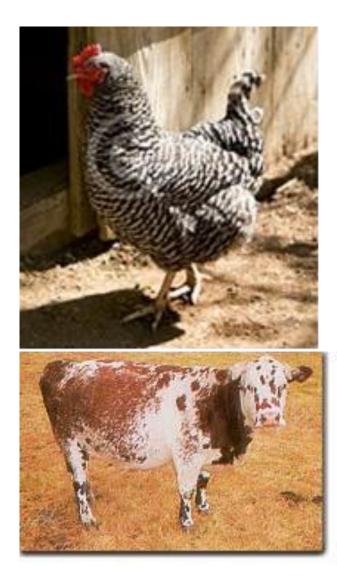
Cross a long tail cat and a short tail cat. What proportion of the offspring will have short tails? Long tails?





## 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



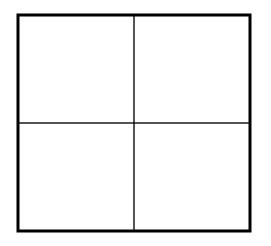
### Codominance

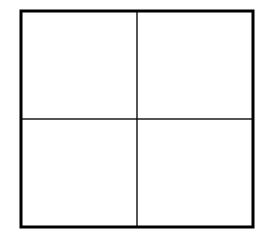
In Erminette chickens, the gene for feather color has two codominant alleles – one for black feathers (F<sup>B</sup>F<sup>B</sup>) and one for white feathers (F<sup>W</sup>F<sup>W</sup>). Heterozygous chickens (F<sup>B</sup>F<sup>W</sup>) have BOTH black and white feathers, resulting in a distinctive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



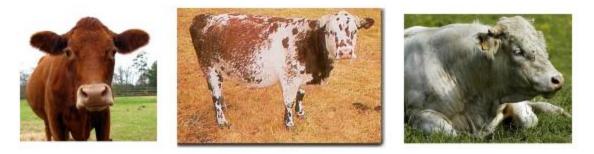
Cross a white chicken and a black chicken.

Cross a black chicken and a speckled chicken.





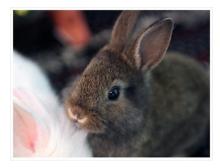
### Codominance



In cows, the allele for red hair (H<sup>R</sup>) and the allele for white hair (H<sup>W</sup>) 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?

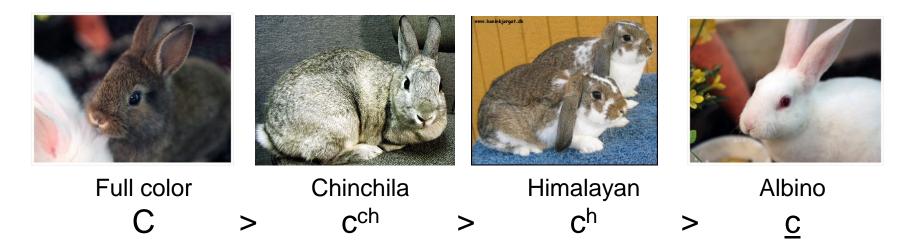

- Rather than two alleles, there maybe 3, 4 or more.
- A hierarchy exists as to which allele is dominant in an individual
- Example:  $C > c^{ch} > c^h > \underline{c}$







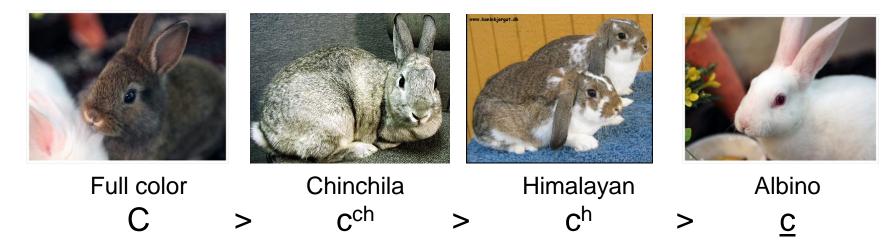




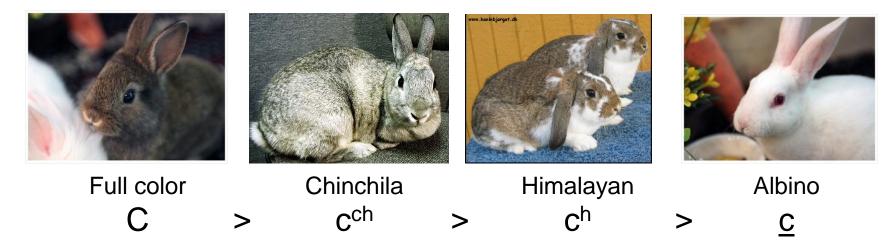
What is the genotype(s) of an albino?

What is the genotype(s) of a Himalayan?

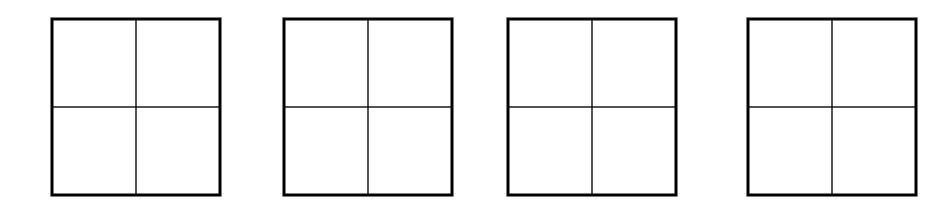
What is the genotype(s) of a full color?



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



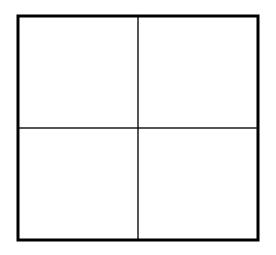
What are the potential outcomes from this test cross?





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.

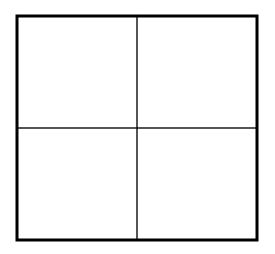
The litter contains 6 Full Color, 3 Himalayan, and 3 Albino





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

### 246 million base pairs

alignant transformation suppression Ehlers-Danlos syndrome, type VI Glaucoma, primary infantile rschsprung disease, cardiac defects Schwartz-Jampel syndrome ophosphatasia, infantile, childhood Breast cancer, ductal Cutaneous malignant melanoma/dysplastic nevus p53-related protein Serotonin receptors Schnyder crystalline corneal dystrophy Kostmann neutropenia Oncogene MYC, lung carcinoma-derived Deafness, autosomal dominant Porphyria Epiphyseal dysplasia, multiple, type 2 Intervertebral disc disease Lymphoma, non-Hodgkin Breast cancer, invasive intraductal Colon adenocarcinoma Maple syrup urine disease, type II Atrioventricular canal defect Fluorouracil toxicity, sensitivity to Zellweger syndrome Stickler syndrome, type III Marshall syndrome Stargardt disease Retinitis pigmentosa Cone-rod dystrophy Macular dystrophy, age-related Fundus flavimaculatus Hypothyroidism, nongoitrous Exostoses, multiple Pheochromocytoma Psoriasis susceptibility Limb-girdle muscular dystrophy, autosomal dominant Pycnodysostosis Vohwinkel syndrome with ichthyosis Erythrokeratoderma, progressive symmetric Anemia, hemolytic Elliptocytosis Pyropoikilocytosis Spherocytosis, recessive Schizophrenia Lupus nephritis, susceptibility to Migraine, familial hemiplegic Emery-Dreifuss muscular dystrophy Cardiomyopathy, dilated Lipodystrophy, familial partial Dejerine-Sottas disease, myelin P-related Hypomyelination, congenital Nemaline myopathy, autosomal dominant Lupus erythematosus, systemic, susceptibility Neutropenia, alloimmune neonatal Viral infections, recurrent Antithrombin III deficiency Atherosclerosis, susceptibility to Glaucoma Tumor potentiating region Nephrotic syndrome Sjogren syndrome Coagulation factor deficiency Alzheimer disease Cardiomyopathy Factor H deficiency Membroproliferative glomerulonephritis Hemolytic-uremic syndrome Nephropathy, chronic hypocomplementemic Epidermolysis bullosa Popliteala pterygium syndrome Ectodermal dysplasia/skin fragility syndrome Usher syndrome, type 2A Kenny-Caffey syndrome Diphenylhydantoin toxicity

Cataracts

Homocystinuria Neuroblastoma (neuroblastoma suppressor) Rhabdomyosarcoma, alveolar Neuroblastoma aberrant in some Exostoses, multiple-like Opioid receptor Hyperprolinemia, type II Bartter syndrome, type 3 Prostate cancer Brain cancer Charcot-Marie-Tooth neuropathy Muscular dystrophy, congenital Ervthrokeratodermia variabilis Deafness, autosomal dominant and recessive Glucose transport defect, blood-brain barrier Hypercholesterolemia, familial Neuropathy, paraneoplastic sensory Muscle-eye-brain disease Medulloblastoma Basal cell carcinoma Corneal dystrophy, gelatinous drop-like Leber congenital amaurosis Retinal dystrophy B-cell leukemia/lymphoma Lymphoma, MALT and follicular Mesothelioma Germ cell tumos Sezary syndrome Colon cancer Neuroblastoma Glycogen storage disease Osteopetrosis, autosomal dominant, type II Waardenburg syndrome, type 2B Vesicoureteral reflux Choreoathetosis/spasticity, episodic (paroxysmal) Hemochromatosis, type 2 Leukemia, acute Gaucher disease Medullary cystic kidney disease, autosomal dominant Renal cell carcinoma, papillary Insensitivity to pain, congenital, with anhidrosis Medullary thyroid carcinoma Hyperlipidemia, familial combined Hyperparathyroidism Lymphoma, progression of Porphyria variegata Hemorrhagic diathesis Thromboembolism susceptibility Systemic lupus erythematosus, susceptibility Fish-odor syndrome Prostate cancer, hereditary Chronic granulomatous disease Macular degeneration, age-related Epidermolysis bullosa Chitotriosidase deficiency Pseudohypoaldosteronism, type I Hypokalemic periodic paralysis Malignant hyperthermia susceptibility Glomerulopathy with fibronectin deposits Metastasis suppressor Measles, susceptibility to van der Woude syndrome (lip pit syndrome) Rippling muscle disease Hypoparathyroidism-retardation-dysmorphism syndrome entricular tachycardia, stress-induced polymorphic Fumarase deficiency Chediak-Higashi syndrome Muckle-Wells syndrome Zellweger syndrome Adrenoleukodystrophy, neonatal Endometrial bleeding-associated factor Left-right axis malformation Prostate cancer, hereditary Chondrodysplasia punctata, rhizomelic, type 2

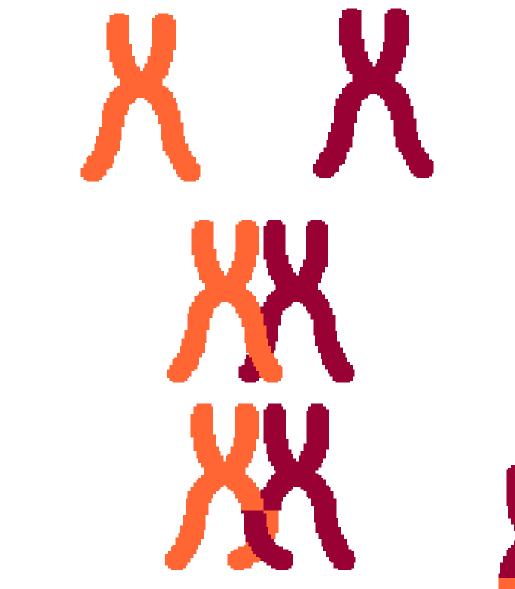
Cataracts Malignant transformation suppression Ehlers-Danlos syndrome, type VI Glaucoma, primary infantile irschsprung disease, cardiac defects Schwartz-Jampel syndrome ophosphatasia, infantile, childhood Breast cancer, ductal Cutaneous malignant melanoma/dysplastic nevus p53-related protein Serotonin receptors Schnyder crystalline corneal dystrophy Kostmann neutropenia Oncogene MYC, lung carcinoma-derived Deafness, autosomal dominant Pomhyria Epiphyseal dysplasia, multiple, type 2 Intervertebral disc disease Lymphoma, non-Hodgkin Breast cancer, invasive intraductal Colon adenocarcinoma Maple syrup urine disease, type II Atrioventricular canal defect Fluorouracil toxicity, sensitivity to Zellweger syndrome Stickler syndrome, type III Marshall syndrome Stargardt disease Retinitis pigmentosa Cone-rod dystrophy Macular dystrophy, age-related Fundus flavimaculatus Hypothyroidism, nongoitrous Exostoses, multiple Pheochromocytoma Psoriasis susceptibility Limb-girdle muscular dystrophy, autosomal dominant Pvcnodysostosis Vohwinkel syndrome with ichthyosis Erythrokeratoderma, progressive symmetric Anemia, hemolytic Elliptocytosis Pyropoikilocytosis Spherocytosis, recessive Schizophrenia Lupus nephritis, susceptibility to Migraine, familial hemiplegic Emery-Dreifuss muscular dystrophy Cardiomyopathy, dilated Lipodystrophy, familial partial Dejerine-Sottas disease, myelin P-related Hypomyelination, congenital Nemaline myopathy, autosomal dominant Lupus erythematosus, systemic, susceptibility Neutropenia, alloimmune neonatal Viral infections, recurrent Antithrombin III deficiency Atherosclerosis, susceptibility to Glaucoma Tumor potentiating region Nephrotic syndrome Sjogren syndrome Coagulation factor deficiency Alzheimer disease Cardiomyopathy Factor H deficiency Membroproliferative glomerulonephritis Hemolytic-uremic syndrome Nephropathy, chronic hypocomplementemic Epidermolysis bullosa Popliteala pterygium syndrome Ectodermal dysplasia/skin fragility syndrome Usher syndrome, type 2A Kenny-Caffey syndrome Diphenylhydantoin toxicity

### 246 million base pairs

Homocystinuria Neuroblastoma (neuroblastoma suppressor) Rhabdomyosarcoma, alveolar Neuroblastoma aberrant in some Exostoses, multiple-like Opioid receptor Hyperprolinemia, type II Bartter syndrome, type 3 Prostate cancer Brain cancer Charcot-Marie-Tooth neuropathy Muscular dystrophy, congenital Ervthrokeratodermia variabilis Deafness, autosomal dominant and recessive Glucose transport defect, blood-brain barrier Hypercholesterolemia, familial Neuropathy, paraneoplastic sensory Muscle-eye-brain disease Medulloblastoma Basal cell carcinoma Corneal dystrophy, gelatinous drop-like Leber congenital amaurosis Retinal dystrophy B-cell leukemia/lymphoma Lymphoma, MALT and follicular Mesothelioma Germ cell tumos Sezary syndrom Colon cancer Neuroblastoma Glycogen storage disease Osteopetrosis, autosomal dominant, type II Waardenburg syndrome, type 2B Vesicoureteral reflux Choreoathetosis/spasticity, episodic (paroxysmal) Hemochromatosis, type 2 Leukemia, acute Gaucher disease Medullary cystic kidney disease, autosomal dominant Renal cell carcinoma, papillary Insensitivity to pain, congenital, with anhidrosis Medullary thyroid carcinoma Hyperlipidemia, familial combined Hyperparathyroidism Lymphoma, progression of Porphyria variegata Hemorrhagic diathesis Thromboembolism susceptibility Systemic lupus erythematosus, susceptibility Fish-odor syndrome Prostate cancer, hereditary Chronic granulomatous disease Macular degeneration, age-related Epidermolysis bullosa Chitotriosidase deficiency Pseudohypoaldosteronism, type II Hypokalemic periodic paralysis Malignant hyperthermia susceptibility Glomerulopathy with fibronectin deposits Metastasis suppressor Measles, susceptibility to van der Woude syndrome (lip pit syndrome) Rippling muscle disease Hypoparathyroidism-retardation-dysmorphism syndrome entricular tachycardia, stress-induced polymorphic Fumarase deficiency Chediak-Higashi syndrome Muckle-Wells syndrome Zellweger syndrome Adrenoleukodystrophy, neonatal Endometrial bleeding-associated factor Left-right axis malformation Prostate cancer, hereditary Chondrodysplasia punctata, rhizomelic, type 2

## 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?



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# 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

