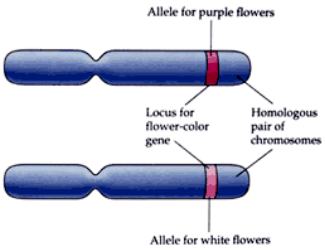
Mendelian Genetics

GENETIC TERMINOLOGY:

- **Trait** = any characteristic that can be passed from parent to offspring
- **Heredity** = passing of traits from parent to offspring
- **Genetics** = study of heredity

GENETIC TERMINOLOGY:

- **Alleles** = two forms of a gene (dominant & recessive)



GENETIC TERMINOLOGY:

- **Dominant** = stronger of two genes expressed in the hybrid; represented by a capital letter (R)
- **Recessive** = gene that shows up less often in a cross; represented by a lowercase letter (r)

GENETIC TERMINOLOGY:

- **Genotype** = gene combination for a trait (ex: RR, Rr, rr)
- **Phenotype** = the physical feature resulting from a genotype (e.g. tall, short)

GENETIC TERMINOLOGY:

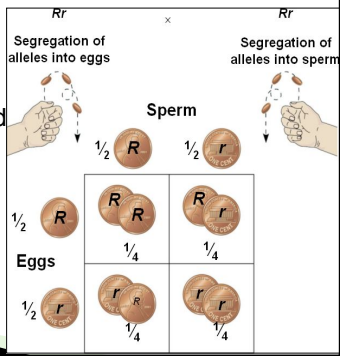
- **Homozygous genotype** = gene combination involving 2 dominant or 2 recessive genes (ex: RR or rr); also called **pure**
- **Heterozygous genotype** = gene combination of one dominant & one recessive allele (ex: Rr); also called **hybrid**

GENETIC TERMINOLOGY:

- **Monohybrid cross** = cross involving a single trait
- **Dihybrid cross** = cross involving two traits

GENETIC TERMINOLOGY:

- **Punnett Square** = used to solve genetics problems. (based on probability)

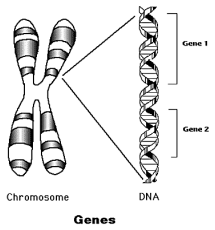


FUNDAMENTALS OF GENETICS

- **HEREDITY** = The passing of traits from **parents** to **offspring.**
  - Transmitted by means of information stored in molecules of **DNA.**

FUNDAMENTALS OF GENETICS

- **GENETCS** is based on knowledge that traits are transmitted by **chromosomes,** which are made up of genes.
- **Genes**, are pieces of DNA that code for certain traits.



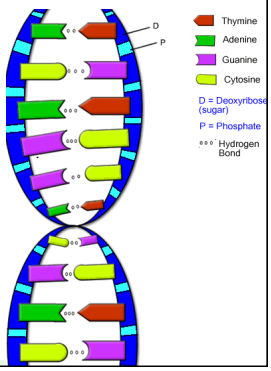
WHAT MAKES YOU WHO YOU ARE TODAY?

- **HEREDITY & ENVIRONMENT**--are the two great influences, acting together all through your life.
- Genetic messages determine what organisms **may** become.
- The interaction of messages and the environment determines what organisms **do** become.

FUNDAMENTALS OF GENETICS

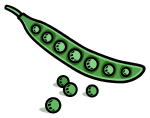
- **ENVIRONMENT** = All the outside forces that act on an organism.
  - Affects the development, later life, and the expression of hereditary traits of an organism.

- **Organisms inherit <u>genetic messages</u>, not traits!**
- Traits develop when genetic messages interact with the environment.



Gregor Mendel

- **GREGOR MENDEL** -"**<u>Father of Genetics</u>**" – (1865) Austrian monk
  - His research with **<u>garden peas</u>** (8 yrs) led to the discovery of the basic principles of heredity.



Gregor Mendel

- studied pea traits, each of which had a dominant & a recessive form **<u>(alleles).</u>**
- The **<u>dominant</u>** gene or allele is represented with a **<u>capital letter</u>** (ex: B)
- **<u>recessive gene</u>** represented with a **<u>lower case</u>** of that same letter (ex: b)

Gregor Mendel

- *Mendel's traits included:*

a. *Seed shape* --- Round (R) or Wrinkled (r)

b. *Seed Color* ---- Yellow (Y) or Green (y)

c. *Pod Shape* --- Smooth (S) or wrinkled (s)

d. *Pod Color* --- Green (G) or Yellow (g)

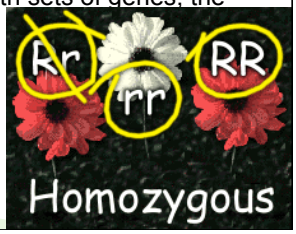
e. *Seed Coat Color* --- Gray (G) or White (g)

f. *Plant Height* --- Tall (T) or Short (t)

g. *Flower color* --- Purple (P) or white (p)

MENDELIAN GENETICS OVERVIEW

- If both of our parents gave us the **<u>same</u>** **<u>type</u>** of gene – the same allele – then we are:
- **HOMOZYGOUS or pure** (on both sets of our chromosomes, on both sets of genes; the allele is the **<u>same</u>**).

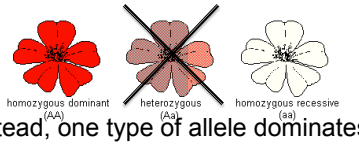


MENDELIAN GENETICS OVERVIEW

- If one parent gave us one type of gene and the other parent gave us a *different* type, then we are:
  - **HETEROZYGOUS or hybrid** – we have two different alleles.

MENDELIAN GENETICS OVERVIEW

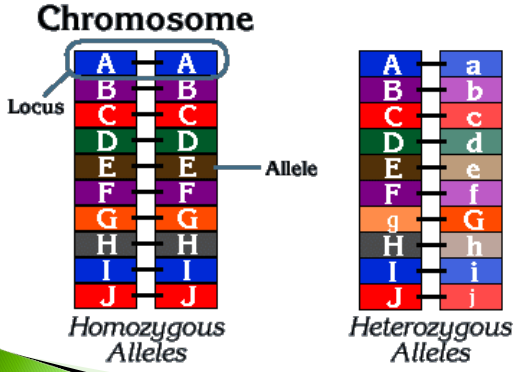
- With MENDELIAN traits (the type of traits that Mendel studied) heterozygotes **DO NOT** have a **blend** of the two alleles.



  - Instead, one type of allele dominates and we show the characteristics of this allele only – it is the **DOMINANT trait**.

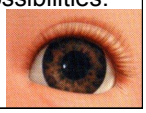
MENDELIAN GENETICS OVERVIEW

- The recessive gene is still there on half of our chromosomes
  - It can still pass to our children, depending on meiosis
  - BUT it **DOES NOT** affect us right now—it is the **RECESSIVE trait.**



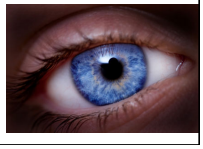
MENDELIAN GENETICS OVERVIEW

- **GENOTYPE** (**type of genes** that we have)
- **PHENOTYPE** trait we **physically** show (the type of allele that is expressed)
- For example, if the **dominant allele** of the eye color gene is **brown** and the **recessive allele** of the eye color gene is **blue**, then the person could have the following possibilities:

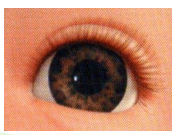
MENDELIAN GENETICS OVERVIEW

1. Two blue alleles, bb (one from **mom**, one from **dad**).
   - Genotype would be ***homozygous recessive***
   - Phenotype would be ***blue-eyed.***



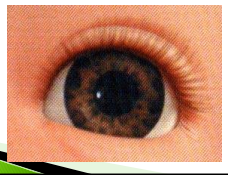
MENDELIAN GENETICS OVERVIEW

2. Two brown alleles, BB (one from mom, one from dad).
   - Genotype would be ***homozygous dominant***
   - Phenotype would be ***brown-eyed.***



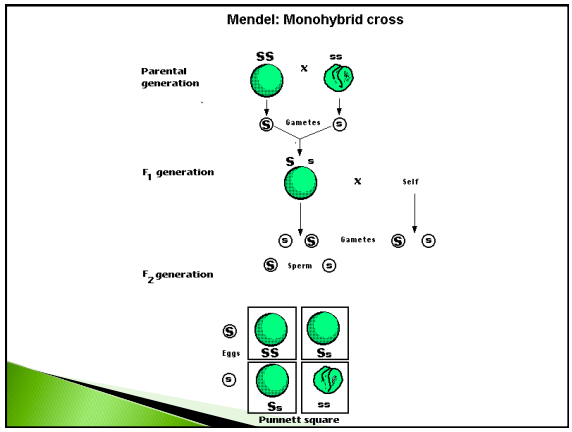
MENDELIAN GENETICS OVERVIEW

3. One brown and one blue allele, Bb (one from mom, one from dad).
   - Genotype would be Heterozygous
   - Phenotype would be brown-eyed.



MENDELIAN GENETICS OVERVIEW

- When only **one** trait is being studied in a genetic cross, it is called a ***monohybrid cross***.
  - When parent organisms, called the ***P generation***, are crossed, the resulting offspring are the first filial, or ***F_1 generation***.
  - When organisms of the F1 generation are crossed, their offspring make up the second filial or, ***F_2 generation***.



MENDEL'S EXPERIMENTS:

- Mendel cross-pollinated two strains and tracked each trait through two generations. (ex: TT x tt)
  - **Trait** = plant height
  - **Alleles** = T (tall), t (short)

MENDEL'S EXPERIMENTS:

- P_1 cross = **TT x tt**

	T	T
t	Tt	Tt
t	Tt	Tt

F_1 Genotypic ratio = **100% Tt**

F_1 Phenotypic ratio = **100% Tall**

MENDEL'S EXPERIMENTS:

	T	T
t	Tt	Tt
t	Tt	Tt

The offspring of this cross were all **hybrids** showing ONLY the **dominant trait** & were called the **First Filial or F_1** generation.

MENDEL'S EXPERIMENTS:

- Mendel then crossed two of his F_1 plants and tracked their traits; known as an **F_1 cross.**
  - **Trait** = plant height
  - **Alleles** = T (tall), t (short)

MENDEL'S EXPERIMENTS:

- F_1 cross = **Tt x Tt**

	T	t
T	TT	Tt
t	Tt	tt

F_2 Genotypic ratio = **1 TT: 2 Tt: 1 tt**

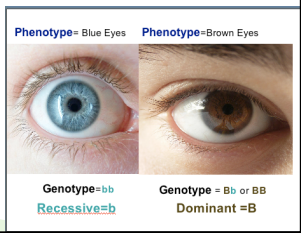
F_2 Phenotypic ratio = **3 Tall: 1 short**

MENDEL'S EXPERIMENTS:

- When 2 hybrids were crossed, 75% (3/4) of the offspring showed the dominant trait & 25% (1/4) showed the recessive trait
- Two hybrids ALWAYS create a **3 (dominant trait): 1 (recessive trait) ratio.**
- The offspring of this cross were called the **F_2 generation**.

RESULTS OF MENDEL'S EXPERIMENTS:

- Inheritable **factors or genes** are responsible for all heritable characteristics.
- **Phenotype** is based on **genotype.**



RESULTS OF MENDEL'S EXPERIMENTS:

- **Each trait** is based on **two genes**, one from the mother and the other from the father.
- True-breeding individuals are homozygous (both alleles) are the same.
- Formulated 3 laws of heredity in the early 1860's.

MENDEL'S 3 LAWS OF HEREDITY:

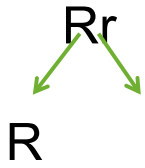
1. **Law of Dominance** states that when different alleles for a characteristic are inherited (heterozygous), the trait of only one (the dominant one) will be expressed. The recessive trait's phenotype only appears in true-breeding (homozygous) individuals.

Law of Dominance

Trait: Pod Color

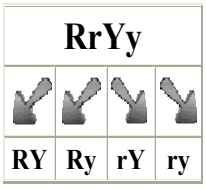
Genotypes:	Phenotype:
GG	Green Pod 
Gg	Green Pod 
gg	Yellow Pod 

2. ***The Law of Segregation*** = states that each genetic trait is produced by a pair of alleles which separate (segregate) during reproduction.



- Explains the disappearance of a specific trait in the F_1 generation and its reappearance in the F_2 generation.

3. ***The Law of Independent Assortment*** = states that each factor (gene) is distributed (assorted) randomly and independently of one another in the formation of **gametes** (egg or sperm).



The Law of Independent Assortment

- Explains that different traits are inherited **independently**, if on different chromosomes
- Ex: wrinkled seeds do not have to be yellow. They can be green.

The Law of Independent Assortment

- Ex: A gamete with RrYy
  - R and r – separate into different gametes
  - Y and y – Separate into different gametes
  - They can then recombine 4 ways to form gametes:
- **RY Ry rY ry**

INHERITANCE OF HUMAN TRAITS: DOMINANT/ RECESSIVE

- **No cleft in chin** / Cleft in chin recessive
- **Straight thumb** / Hitch-hiker's thumb

- **Hair on back of hand** / no hair on back of hand
- **Inability to fold tongue**/ ability to fold tongue
- **Tongue roller**/ Non-roller

INHERITANCE OF HUMAN TRAITS: DOMINANT/ RECESSIVE

- **Dark hair**/ Light hair
- **Non-red hair**/ Red hair
- **Widows peak**/ Straight or curved hairline
- **White forelock**/ Normal hair
- **Freckles**/ Normal
- **Dimples**/ No dimples

INHERITANCE OF HUMAN TRAITS: DOMINANT/ RECESSIVE

- **Brown eyes**/ Blue eyes
- **Normal eyesight**/ Nearsighted
- **Almond shaped eyes**/ Round eyes
- **Long eyelashes**/ Short eyelashes
- **Broad nostrils**/ Narrow nostrils
- **Roman nose**/ Straight nose

INHERITANCE OF HUMAN TRAITS: DOMINANT/ RECESSIVE

- **Free ear lobe**/ Attached ear lobe
- **Bent little fingers**/ Parallel little fingers
- **Left over right thumb**/ Right over left thumb

Attached earlobe

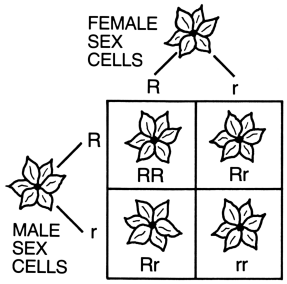
Unattached earlobe

INHERITANCE OF HUMAN TRAITS: DOMINANT/ RECESSIVE

- **A or B blood**/ O blood
- **RH+ blood**/ RH- blood
- **Normal clotting**/ Hemophilia
- **Normal** / Allergy

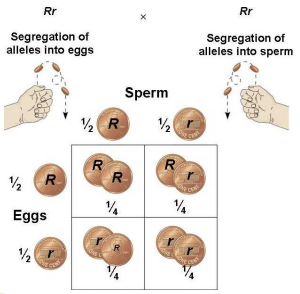
Punnett Squares

- Use Punnett Squares to solve genetic problems!



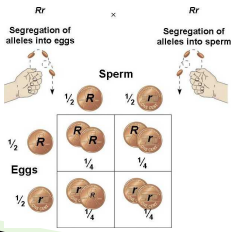
Punnett Squares:

- Ex: Crossing two heterozygous genotypes (**Rr** x **Rr**)



Punnett Squares:

- *Remember the letters of a genotype (R, r's) represent possible **gamete** (egg/sperm) combinations.*



Test Cross Punnett Square:

- If an organism shows the **dominant** trait, you can't tell if it is heterozygous (Rr) or homozygous(RR) for that trait
- To determine the genotype of that organism a **test cross** would be done.
- **Test cross** = the organism of ***unknown dominant genotype*** is crossed with a **homozygous recessive** (rr) organism.

IN CLASS PRACTICE PROBLEMS – MONOHYBRIDS (one trait)

- Black coat color in guinea pigs is dominant over white coat color.
- Using a Punnett square, show the results of crossing a hybrid black with pure white. Then show the results of crossing a hybrid black and a hybrid black.

IN CLASS PRACTICE PROBLEMS – MONOHYBRIDS (one trait)

Black Trait – **B (dominant)**

White Trait – **b (recessive)**

Hybrid black – **Bb**

Pure white – **bb**

IN CLASS PRACTICE PROBLEMS – MONOHYBRIDS (one trait)

- P_1 cross: **Bb x bb**

	B	b
b	Bb	bb
b	Bb	bb

Genotypes of F_1 offspring
2 Bb : 2 bb

Phenotypes of F_1 offspring–
2 black : 2 white
(or 50% black and 50% white)

IN CLASS PRACTICE PROBLEMS – MONOHYBRIDS (one trait)

Black Trait – **B (dominant)**

White Trait – **b (recessive)**

Hybrid black – **Bb**

Hybrid black – **Bb**

IN CLASS PRACTICE PROBLEMS – MONOHYBRIDS (one trait)

- P_1 cross: **Bb x Bb**

	B	b
B	BB	Bb
b	Bb	bb

Genotypes of F_1 offspring

1BB: 2Bb: 1bb

Phenotypes of F_1 offspring–

3Black: 1white

NOW YOU TRY SOME:

1.) In pigs, the white color (**W**) is **dominant**; the black color (**w**) is **recessive**. Using Punnett squares, show the expected results of the following crosses.

1a) A pure (homozygous) white pig is mated with a black pig.

- P_1 cross: **WW x ww**

	W	W
w	Ww	Ww
w	Ww	Ww

F_1 **G:** **100% Ww**

F_1 **P:** **100% White**

b) Show a cross between two of the F_1 offspring from number 1a. Determine the genotypes and phenotypes of the offspring in the F_2 generations.

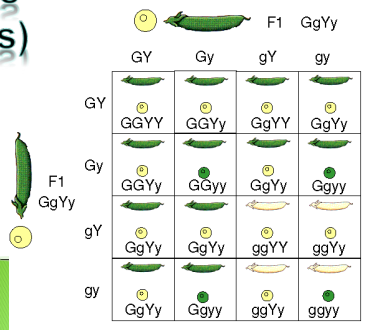
- P_1 cross: **Ww x Ww**

	W	w
W	WW	Ww
w	Ww	ww

F_2 **G:** **1WW: 2Ww: 1ww**

F_2 **P:** **3White: 1black**

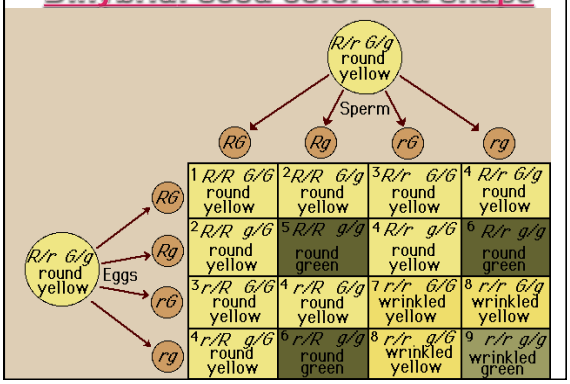
Dihybrids (two traits)



Dihybrids (two traits)

- Because each parent and offspring are using **two** traits, each one should have **4** alleles, **2** for each **trait**.
- Each gamete produced by the P_1 generations will contain 2 alleles, one for each trait.

Dihybrid: seed color and shape



Dihybrids (two traits)

- Example: A plant that is heterozygous for being tall and having green seeds is crossed with a homozygous yellow and short
  - Traits = seed color and plant height
  - Alleles **G** =green **T** = tall
    g = yellow **t** = short

Cross: TtGg x ttgg

Dihybrids (two traits)

- Determine the gametes produced by each parent by using the FOIL method.

  (First Outer Inner Last)

  - TtGg produces 4 different gametes:
    TG Tg tG tg
  - ttgg produces only 1 gamete: tg

	TG	Tg	tG	tg
tg	TtGg	Ttgg	ttGg	ttgg
tg	TtGg	Ttgg	ttGg	ttgg
tg	TtGg	Ttgg	ttGg	ttgg
tg	TtGg	Ttgg	ttGg	ttgg

Phenotypes:
4 tall/green seeds
4tall/yellow seeds
4short/green seeds
4short/yellow seeds

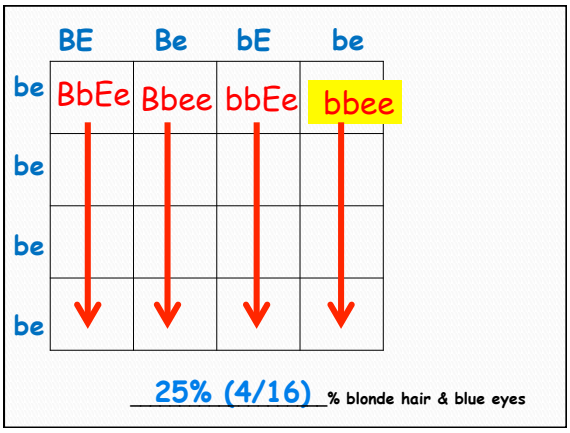
Genotypes:
4TtGg:
4Ttgg:
4ttGg:
4ttgg

DIHYBRID (2 traits) HOMEWORK SET

- Dihybrid cross (two traits are considered) the number of possible combinations of the offspring increases.
- Suppose that **black hair (B) is dominant** over blonde hair (b) and **brown eyes (E) are dominant** over blue (e).
- What percent of offspring could be expected to have blonde hair and blue eyes if:

DIHYBRID (2 traits) HOMEWORK SET

- The father has black hair (heterozygous) and brown eyes (heterozygous) and the mother has blonde hair and blue eyes.
- **Genotype of father =** BbEe
- **Genotype of mother =** bbee
- Complete the cross using the Punnett square. Determine what percent of offspring will have blonde hair and blue eyes.



DIHYBRID (2 traits) HOMEWORK SET

- Both parents have black hair (heterozygous) and brown eyes (heterozygous).
- **Genotype of father =** BbEe
- **Genotype of mother =** BbEe
- Complete the Punnett square below. Determine what percent of offspring will have blonde hair and blue eyes.