Biology **Unit 7** **Genetics**

7:1 Genetics

Gregor Mendel:

- Austrian monk
- Studied the inheritance of traits in pea plants
- His work was not recognized until the 20th century
- Between 1856 and 1863, Mendel cultivated and tested some 28,000 pea plants
- Found that plants offspring retained traits of the parents
- Considered the "Father of Genetics"

You are who you are due to the interaction of HEREDITY and ENVIRONMENT.

<u>ENVIRONMENT</u>: all outside forces that act on an organism.

<u>HEREDITY</u>: traits that are passed from parents to offspring.

<u>GENETICS</u>: the scientific study of heredity.

7:2 Types of Genetic Crosses

MONOHYBRID CROSS: cross analyzing the probability a inheriting a single trait

ALLELE: one half of a gene, comes from either the mother or the father.

Alleles may be symbolized by using capital or lower case letters.

T → allele for tall stem trait

t → allele for short stem trait

GENOTYPE: symbols representing the alleles present in a gene in the cells of an organism. EX: TT, Tt, tt

PHENOTYPE: the trait caused by a gene; what you can see. EX: Tall plant, short plant

DOMINANT ALLELE: allele whose trait is expressed

RECESSIVE ALLELE: allele whose trait is not express because it is overruled by the dominant allele

HOMOZYGOUS: genotype in which both alleles of a gene are the same. EX: TT → homozygous dominant

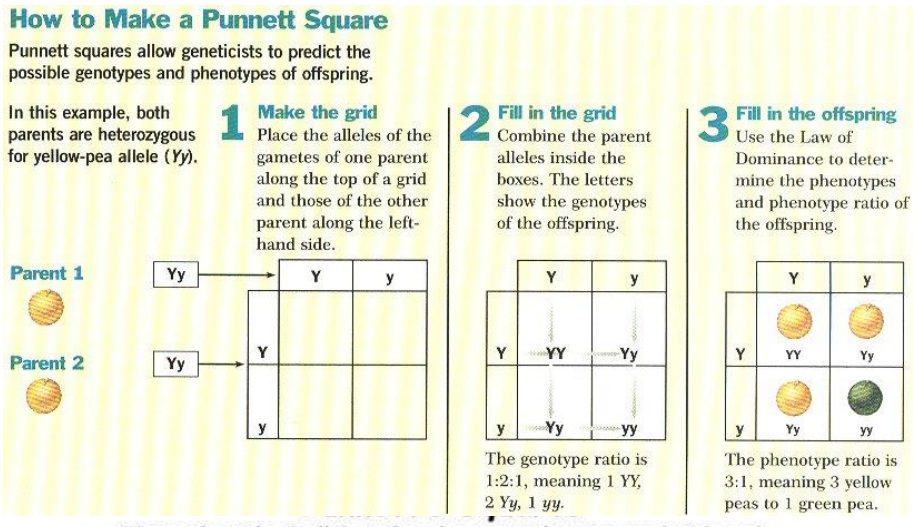
tt → homozygous recessive

HETEROZYGOUS: genotype in which the two alleles of a gene are different; hybrid. EX: Tt → heterozygous

TO MAKE A PUNNETT SQUARE

1. Draw a square and select a trait to study.

2. List alleles for all possible male gametes across top of the square.
3. List alleles for all possible female gametes down the side of the square.
4. Fill in the square by placing one female gamete and one male gamete in each square.



These show the 2 alleles of each parent plant crossed with each other and the resulting 4 possible offspring with T = tall, t = short.

TT = dominant tall, tt = recessive short, Tt = mixed hybrid

TT = dominant tall (genotype tall, phenotype tall)
Tt = mixed hybrid (genotype hybrid, phenotype tall)
tt = recessive short (genotype short, phenotype short)

Using the Punnett's Squares below, name the offspring of all possible parent combinations.

	T	T
T		
T		

Both parents are dominant tall, name the 4 possible offspring.

1. _____ 2. _____

3. _____ 4. _____

	T	t
T		
t		

Both parents are mixed hybrids, name the 4 possible offspring and the expected ratio.

1. _____ 2. _____

3. _____ 4. _____

	T	T
T		
t		

One parents is dominant tall, one is mixed hybrid, name the 4 possible offspring.

1. _____ 2. _____

3. _____ 4. _____

	t	t
t		
t		

Both parents are recessive short, name the 4 possible offspring.

1. _____ 2. _____

3. _____ 4. _____

7:3 What did Mendel do?

MENDEL USED PEA PLANTS TO STUDY HEREDITY FOR TWO REASONS

1. He could easily identify 7 different characteristics and two opposing traits for each characteristic.

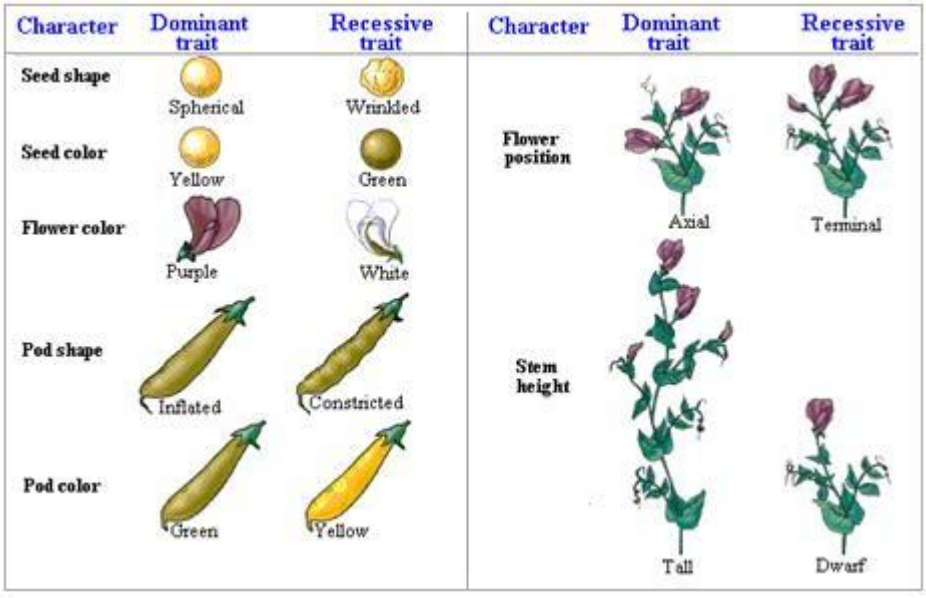
   CHARACTERISTIC: a hereditary quality of an organism.

   EX: stem length, seed color

   TRAIT: contrasting or opposing forms of a characteristic that can be passed passed from parent to offspring .

   EX: tall stem or short stem

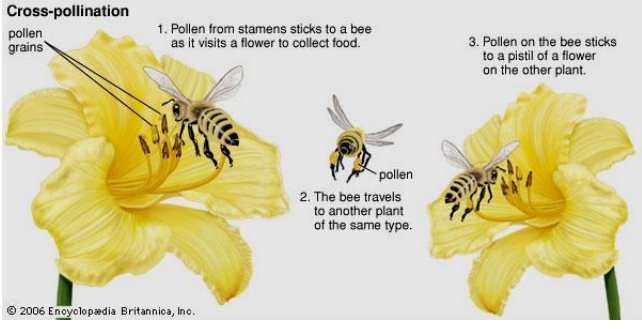
   yellow seed or green seed



2. He could control the fertilization of pea plants, because each plant has both male and female reproductive organs.

   SELF-POLLINATION: when pollen (sperm) from a plant fertilizes an egg on the same plant.

   CROSS-POLLINATION: when pollen from one plant fertilizes an egg on another plant.



- Mendel hand-pollinated flowers using a paintbrush.
- He could snip the anther and stamens (male parts) to prevent self-pollination or cross-pollination
- Covered each flower with a cloth bag, to control the pollination

MENDEL WAS SUCCESSFUL BECAUSE:

1. He studied only one characteristic at a time.
2. He kept detailed quantitative records of his work.

7:4 Mendel's Experiments

Three Steps of Mendel's Experiments

Step One: Mendel observed self pollination in peas plants.

TRUE-BREEDING: organisms that always produce a specific trait when they self-pollinate (P_1 generation)

PARENTAL (P_1) GENERATION: parents with two different traits.

RESULTS: Plants kept the same traits generation after generation.

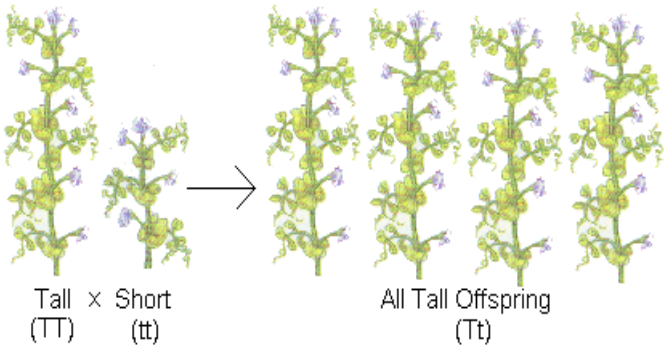
EX: Tall plants always produce tall offspring when self-pollinating, short always produce short.

Step Two: Mendel cross-pollinated plants with contrasting traits.

FIRST FILIAL (F_1) GENERATION: offspring of the P_1 parents, have only one of the two parental traits.

RESULTS: All of the F_1 offspring exhibited the same trait, they looked like only one of the parents.

EX: P_1 Tall X Short
F_1 ALL Tall

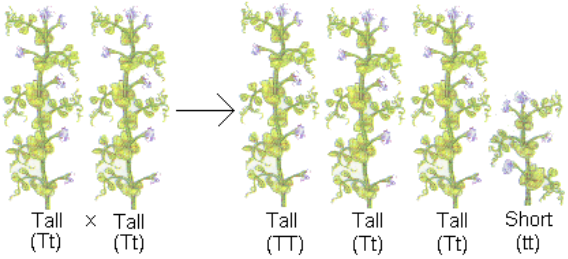


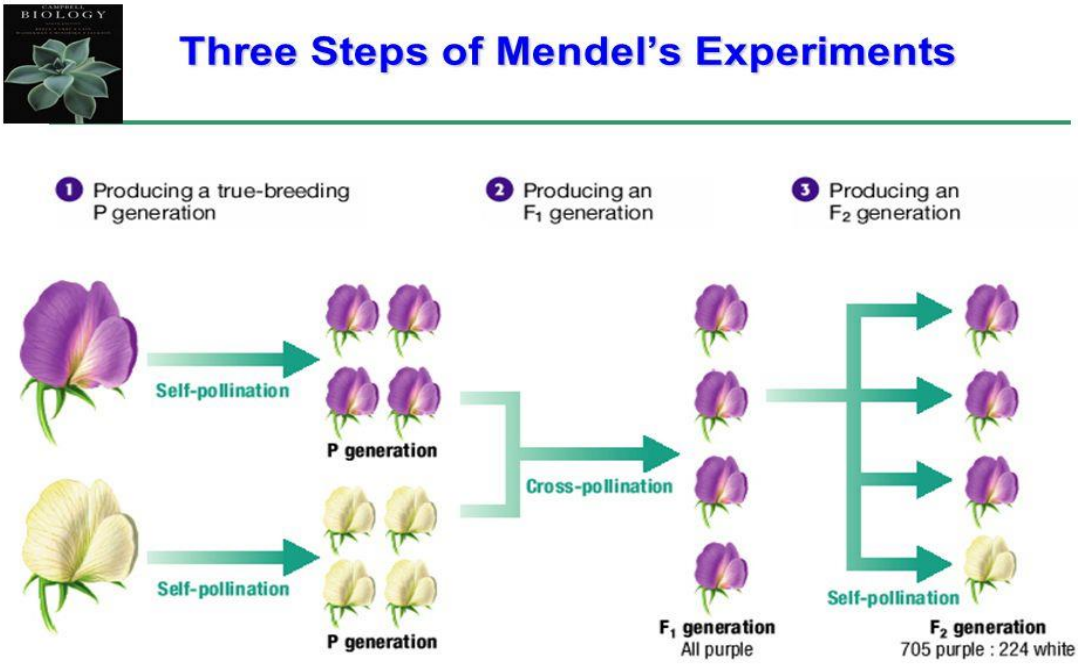
Step Three: Mendel allowed the F_1 generation to self-pollinate.

SECOND FILIAL (F_2): offspring of the F_1generation.

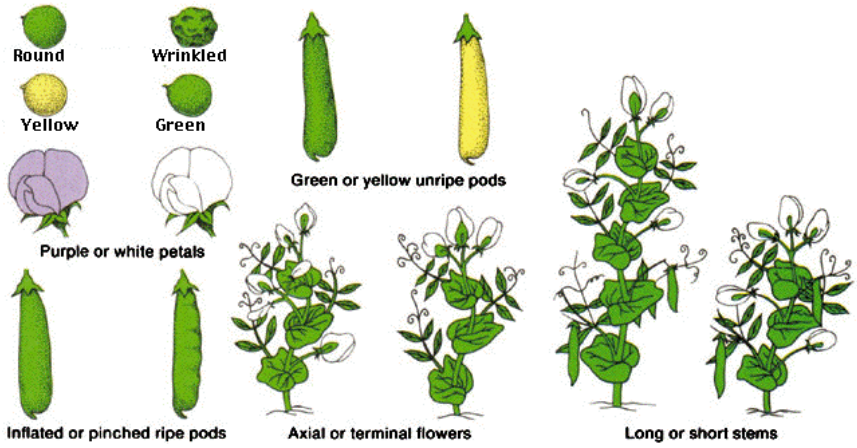
RESULTS: In the F_2 generation ¾ had one trait, ¼ had the contrasting trait.

EX: P_1 tall X short
F_1 All tall
F_2 ¾ tall and ¼ short





The trait on the left is dominant and the trait on the right is recessive



Results of Mendel's Monohybrid Crosses

Characteristics	P_1 Contrasting Traits	F_1 Results	F_2 Results	Observed F_2 Ratio
Seed Shape	Round X wrinkled seed	Round	5474 Round 1850 wrinkled	2.96:1
Seed Color	Yellow X green seed	Yellow	6022 Yellow 2001 green	3.02:1
Flower Color	Purple X white flower	Purple	705 Purple 224 white	3.15:1
Pod Shape	Inflated X constricted pod	Inflated	882 Inflated 299 constricted	2.95:1
Pod Color	Green X yellow pod color	Green	428 Green 152 yellow	2:82:1
Flower Position	Axial X terminal flower	Axial	651 Axial 207 terminal	3.14:1
Stem Height	Tall X short	Tall	787 Tall 277 short	2.84:1

PROBABILITY: likelihood that a specific event will occur

$$Probability = \frac{\text{\# of times an event is expected to happen}}{\text{\# of times an event could happen}}$$

We use Punnett squares to determine the probability, or theoretical ratio.

Example:

- Theoretical ratio of plants producing round seeds to wrinkled seeds is 3:1
- Mendel's observed ratio was 2.96:1
- Statistical Error accounts for the difference between theoretical and observed ratios
- The larger the sample, the more the theoretical and observed ratios are the same.

Conclusion of the result in the above table:

- The heterozygous F_1 generation expresses the dominant trait.
- In the F_2 generation, offspring may express either the dominant or the recessive trait.
- In the F_2 generation, the dominant to recessive ratio is 3:1 (75% dominant, 25% recessive).

7:5 Mendel's Laws

1. Genes Determine Characteristics: Inherited characteristics (traits) are determined by genes, genes consist of two alleles (1 gene = 2 alleles).
   GENE: unit of heredity which determines the trait expressed for a characteristic, enough DNA to code for one protein.
   ALLELE: one half of a gene, comes from either the mother or the father.

ALLELE from mom + ALLELE from dad = GENE of offspring

2. Law of Dominance: One allele of the pair of a gene may mask the other allele, preventing it from expressing its effect.

DOMINANT ALLELE: allele whose trait is expressed
RECESSIVE ALLELE: allele whose trait is not express because it is overruled by the dominant allele

EX: Tall allele is dominant T
Short allele is recessive t

GENE		TRAIT
TT	pure tall	Tall
tt	pure short	short
Tt	hybrid tall	Tall

HYBRID: an organism that expresses the dominant trait, but carries both the dominant and recessive allele.

3. Law of Segregation: The alleles in the pair of a gene are separated during formation of gametes (egg or sperm).
GAMETES: haploid reproductive sex cells, have only one allele of each gene.

EX: pure tall plant (TT)→ all gametes have tall allele (T)
pure short plant (tt)→ all gametes have short allele (t)
hybrid tall plant (Tt)→ ½ gametes have tall allele (T)
½ gametes have short allele (t)

4. Law of Independent Assortment: The allele pair of one gene is separated and distributed to gametes (egg & sperm) independently of all other genes.
EX: alleles for height gene have no connection with alleles for the seed color gene→

Parent gene → TtYy
Possible gametes → TY, Ty, tY, ty

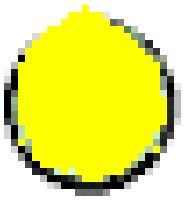
7:6 Dihybrid Crosses

DIHYBRID CROSS: cross analyzing the probability of inheriting two traits at the same time

Practice Making Gametes (Independent Assortment)

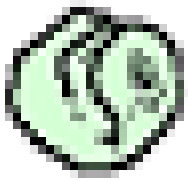
What are the possible gametes this parent can make?

- Homozygous Round Yellow (RRYY)
  - _____
  - _____
  - _____
  - _____



What are the possible gametes this parent can make?

- Homozygous Wrinkled Gametes (rryy)
  - _____
  - _____
  - _____
  - _____



So, what will be the result of all the gametes? _____

What are the possible gametes this parent can make?

- Heterozygous Round Smooth (RrSs)
  - _____
  - _____
  - _____
  - _____

Complete a dihybrid cross for TWO parents that are RrSs.

What are the results?

_____

_____

_____

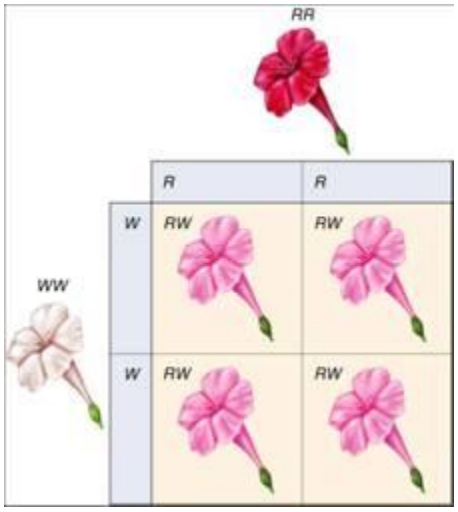
_____

A heterozygous dihybrid cross is a _____ ratio in offspring.

7:7 Incomplete Dominance and Codominance

<u>INCOMPLETE DOMINANCE</u>: when neither allele of a gene is dominant and both affect the phenotype.

EX: Four-o-clock flowers
Characteristic – flower color
R=allele for red color
W=allele for white color



Genotypes	Phenotypes
RR	Red
RW	Pink
WW	White

⇒ Cross a red flower plant with a white flower plant.

	R	R
W	RW	RW
W	RW	RW

All offspring are heterozygous (RW) and have the PINK flower color trait.

⇒ Cross two of the heterozygous pink.

	R	W
R	RR	RW
W	RW	WW

Genotype: 1 RR
2 RW
1 WW

Phenotype: 1 Red
2 Pink
1 White

CODOMINANCE: occurs when both alleles for a gene are expressed in a heterozygous offspring

- Both traits are expressed at the same time, no blending

Example: blood type is the codominance or combination of your parent's blood type

1. Type A= I^AI^A or I^Ai
2. Type B= I^BI^B or I^Bi
3. Type AB= I^AI^B
4. Type O= ii

Monohybrid Cross:

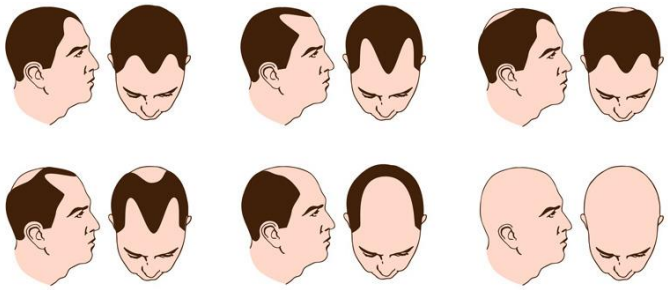
Homozygous Male Type B (I^BI^B) x Heterozygous Female Type A (I^Ai)

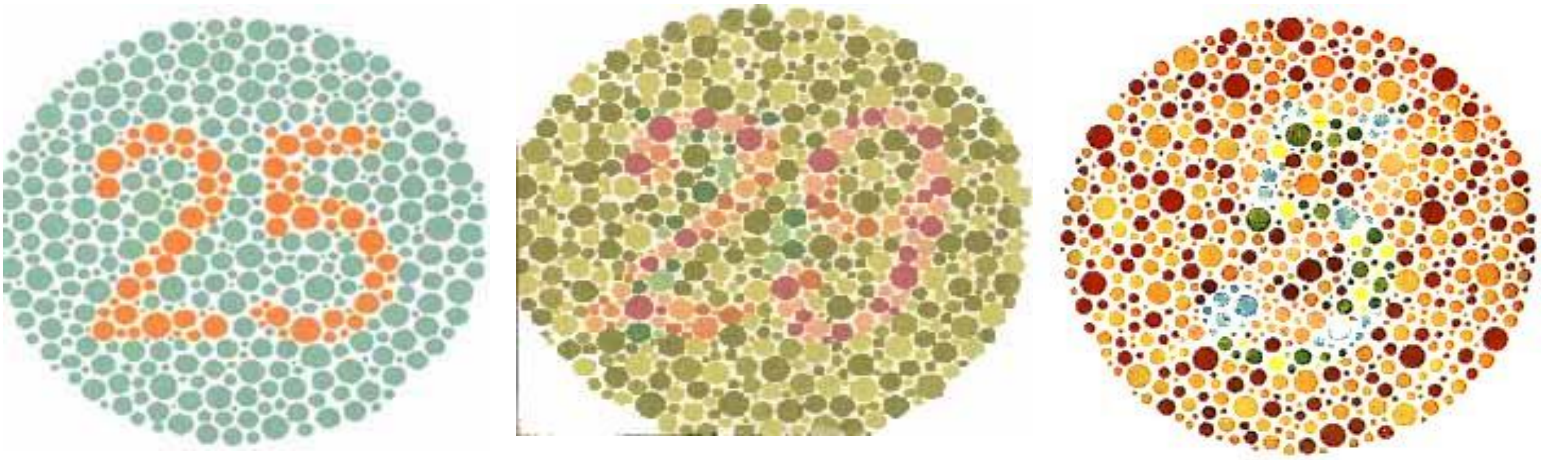
Heterozygous Male Type AB (I^AI^B) x Female Type O (ii)

7:8 Sex-Linked Traits, Polygenic Traits, Single-Allele Traits, and Epistasis

SEX-LINKED TRAIT: a trait that is determined by a gene found on one of the sex chromosomes, such as the X chromosome or the Y chromosome in humans

- Many sex-linked traits are carried on the X chromosome because the X chromosome is larger than the Y chromosome
- Examples: Male pattern baldness, Hemophilia, Red-Green Color Blindness, Muscular Dystrophy





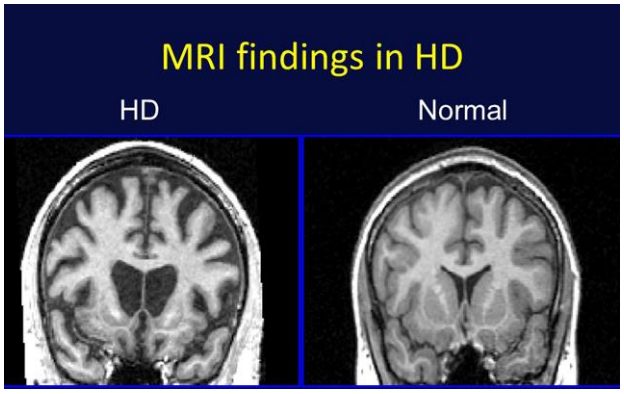
People with Red-Green Blindness can see the second picture.

POLYGENIC: describes a characteristic that is influenced by many genes

- Examples: Skin color, Height, Hair Color, Body Shape, Eye Color

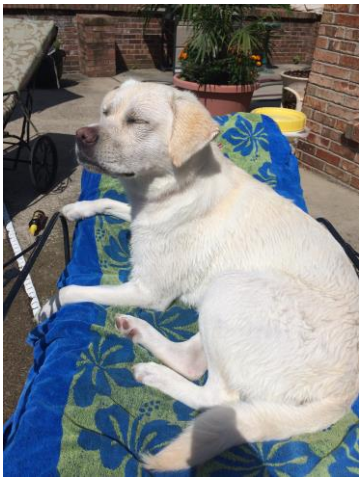
SINGLE-ALLELE TRAIT: traits that are expressed with only one allele

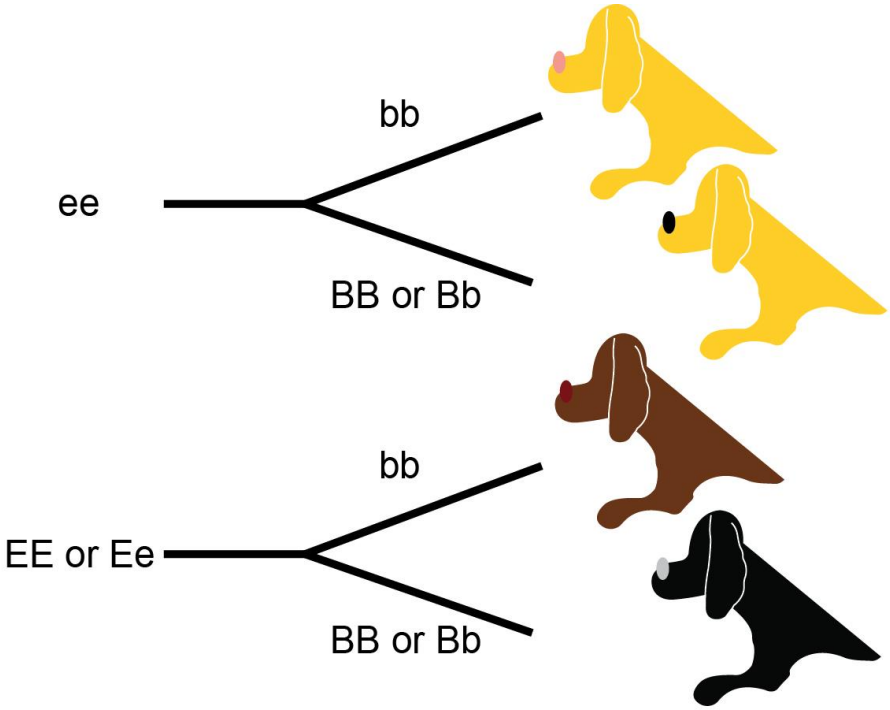
- Example: Huntington's Disease-autosomal dominant condition that causes forgetfulness, irritability, and muscle spasms



EPISTASIS: the interaction between two or more genes to control a single phenotype

- Example: Labrador retriever Coat Color, coat color is determined by two genes the E gene and B gene.
- Yellow fur→homozygous recessive ee
- Black or Chocolate fur→ could be EE or Ee
  - Black→Could be BB or Bb because B is more pigmented
  - Chocolate->homozygous recessive bb





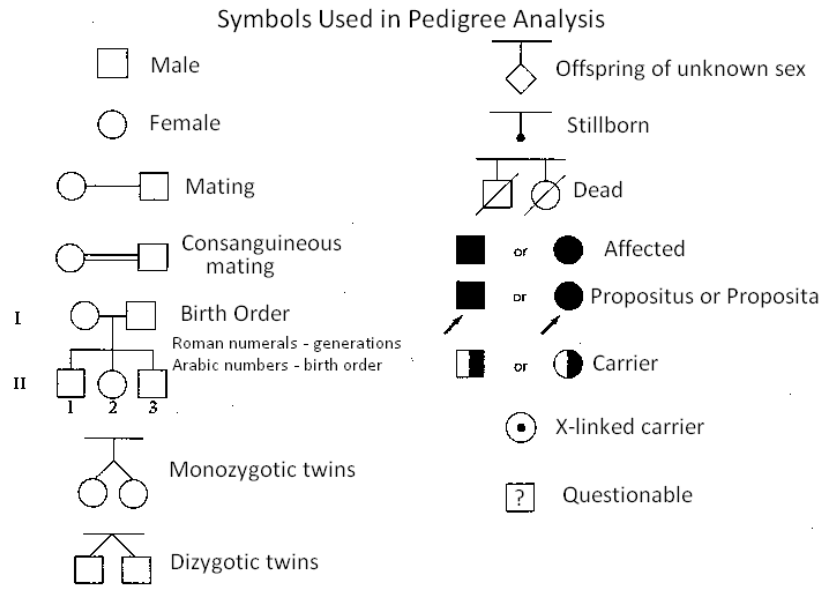
- Example: Albinism in humans→When the albino condition occurs, the genes that determine skin color are present but are not expressed

7:9 Pedigrees

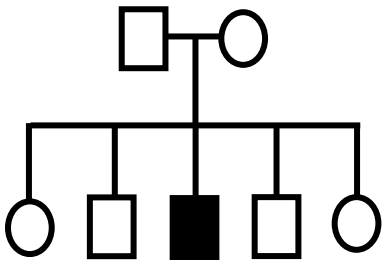
PEDIGREE: family record that shows how a trait is inherited over several generations

Pedigrees may be used for:

- Revealing CARRIERS: a person who is heterozygous for a trait; usually used when referring to a genetic disease
- Determining if a trait is dominant, recessive, or sex linked.
- Show the record of the family of an individual



A marriage with five children, two daughters and three sons. The eldest son is affected by the condition.



Eldest child ↔ Youngest child

Terms used in Pedigree Analysis:

- MONOZYGOTIC: identical twins, arising from one egg and one sperm
- DIZYGOTIC: fraternal twins, arising from two eggs and two sperm

Organizing the Pedigree Chart:

- Generations are identified by Roman Numerals
- Individuals in each generation are identified by numbers from left to right.