MENDELIAN GENETCS

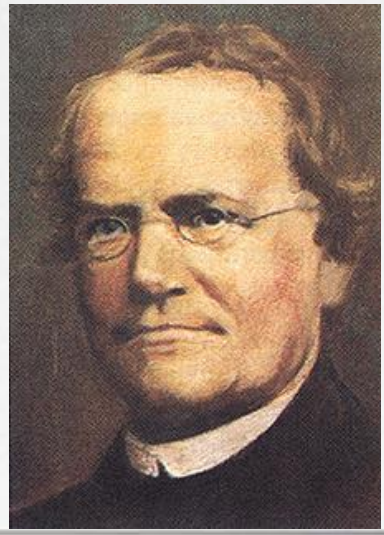
- Modern genetics had its beginnings in an monastery

  garden, where a monk named Gregor Mendel documented a particulate mechanism of inheritance.

- He discovered the basic principles of heredity by breeding garden peas in carefully planned experiments.

- His approach to science had been influenced at the University of Vienna by one of his professors: the physicist Doppler.

- He crossed 28,000 peas Between 1856 and 1863



Underestimetad during 30 years rediscovered by

-Carl Erich Correns (1864-1933) (Germany)

-Erich Tschermak von Seysenegg (1871-1962) (Austria)

-Hugo Marie de Vries (1845-1935) (Holand)

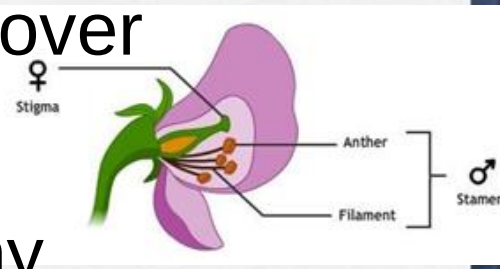
- Before Mendel "blending theory"

http://www.scientificamerican.com/article.cfm?id=making-scents-of-sounds-n

Mendel's impact

- Mendel's theories of inheritance, first discovered in garden peas, are equally valid for figs, flies, fish, birds and human beings.
- Mendel's impact endures, not only on genetics, but on all of science, as a case study of the power of hypothesis/deductive thinking.

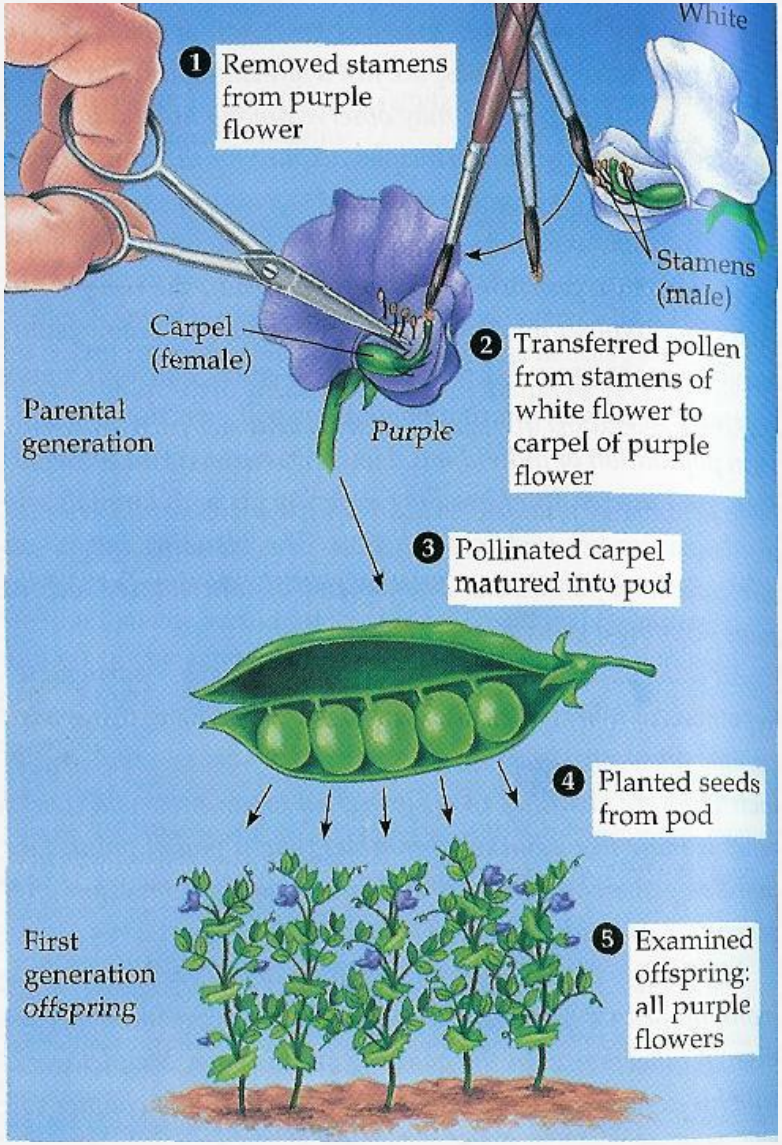
- **Why peas???**
- In order to study inheritance, Mendel chose to use peas, probably as they are available in many varieties.
- The use of plants also allowed strict control over the mating through the *hermaphroditism*



- pea plants reproduce rapidly, and have many visible traits
- He chose to study only characters that varied in an ‘either-or’ rather than a ‘more-or-less’ manner.

Genetic crosses

- To hybridise 2 varieties of pea plants, Mendel used an artist's brush.
- He transferred pollen from a true breeding white flower to the carpel of a true breeding purple flower.



- Seed coat colour (gray or white)
- Seed shape (round or wrinkled)
- Seed colour (yellow or green)
- Pod colour (green or yellow)
- Flower position (axial or terminal)
- Pod shape (inflated or constricted)
- Stem length (tall or dwarf)

Character studied	Dominant trait	Recessive trait
Seed shape	smooth 	wrinkled 
Seed color	yellow 	green 
Pod shape	inflated 	wrinkled 
Pod color	green 	yellow 

What Do the Peas Look Like?

Flower color	purple 	white 
Flower position	on stem 	at tip 
Stem length	tall 	dwarf 

Particulate Inheritance

- Mendel stated that physical traits are inherited as “particles”
- Mendel did not know that the “particles” were actually Chromosomes & DNA

Genetic Terminology

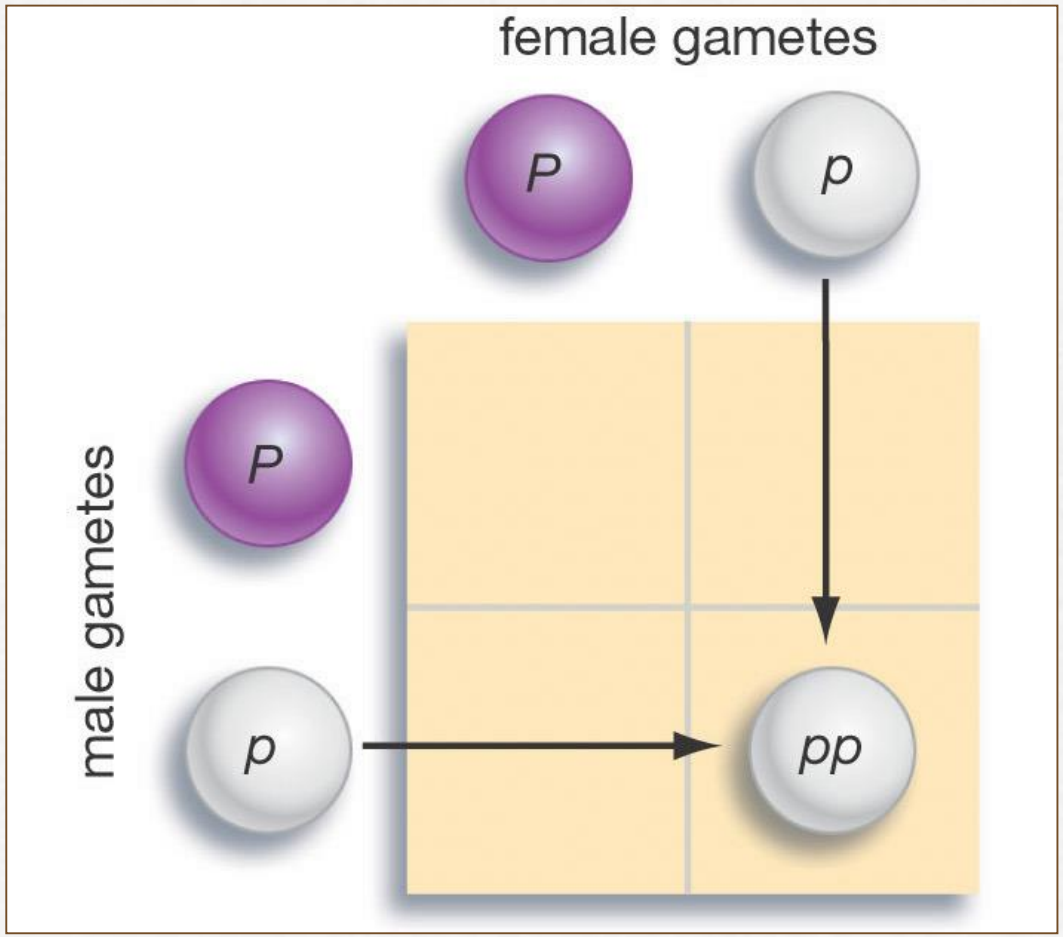
- Trait - any characteristic that can be passed from parent to offspring
- Monohybrid cross - cross involving a single trait e.g. flower color
- Dihybrid cross - cross involving two traits e.g. flower color & plant height

- Genotype is the letter or term used to describe the allele of an individual gene or pair of genes

- Phenotype – is how the gene (or pair) shows itself, how it appears.

Punnett Square

Used to help solve genetics problems



How to Make a Punnett Square

Punnett squares allow geneticists to predict the possible genotypes and phenotypes of offspring.

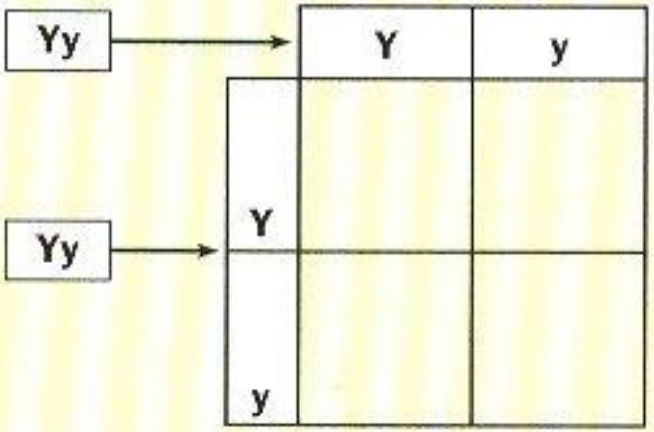
In this example, both parents are heterozygous for yellow-pea allele (*Yy*).

1 Make the grid

Place the alleles of the gametes of one parent along the top of a grid and those of the other parent along the left-hand side.

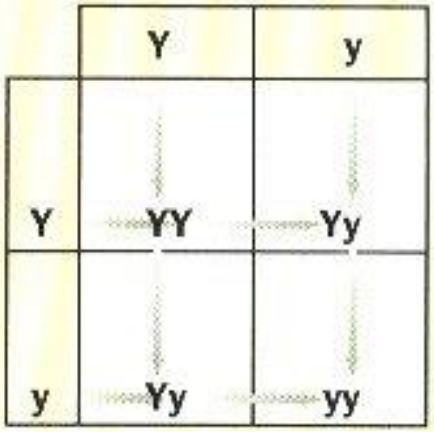
Parent 1

Parent 2



2 Fill in the grid

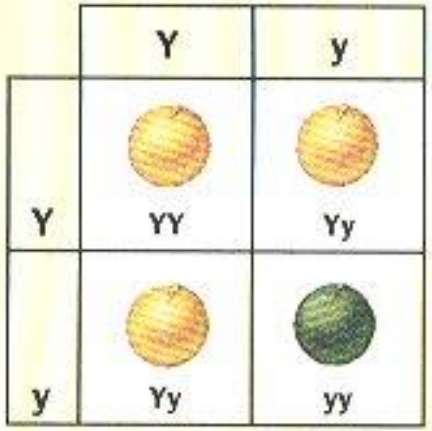
Combine the parent alleles inside the boxes. The letters show the genotypes of the offspring.



The genotype ratio is 1:2:1, meaning 1 *YY*, 2 *Yy*, 1 *yy*.

3 Fill in the offspring

Use the Law of Dominance to determine the phenotypes and phenotype ratio of the offspring.

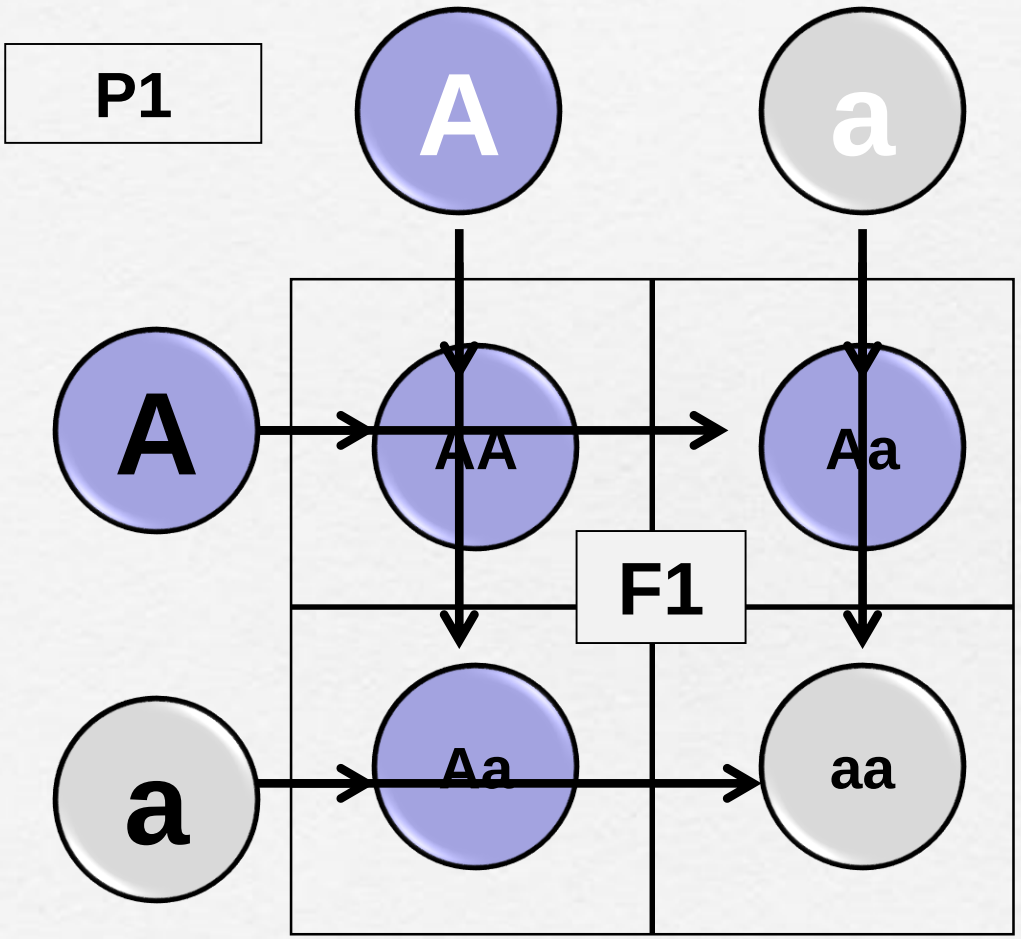


The phenotype ratio is 3:1, meaning 3 yellow peas to 1 green pea.

Punnett

Aa female

Aa male

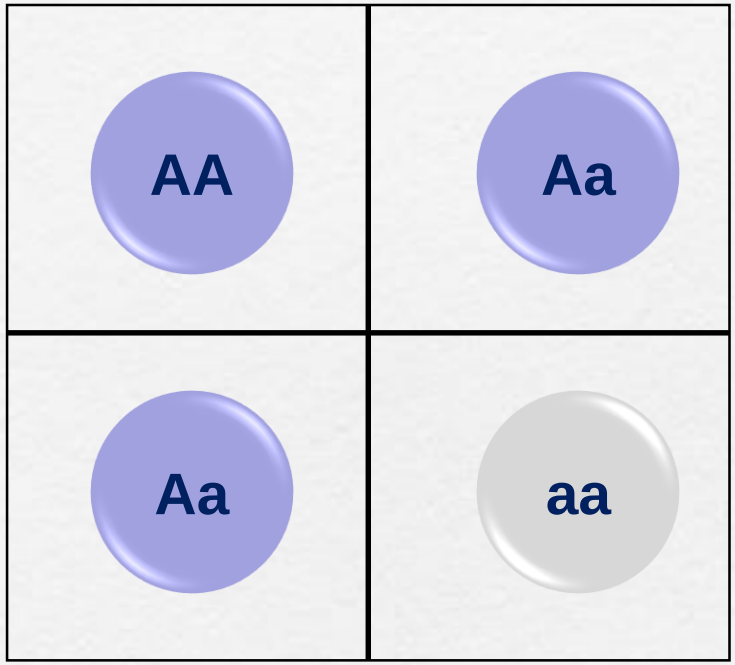


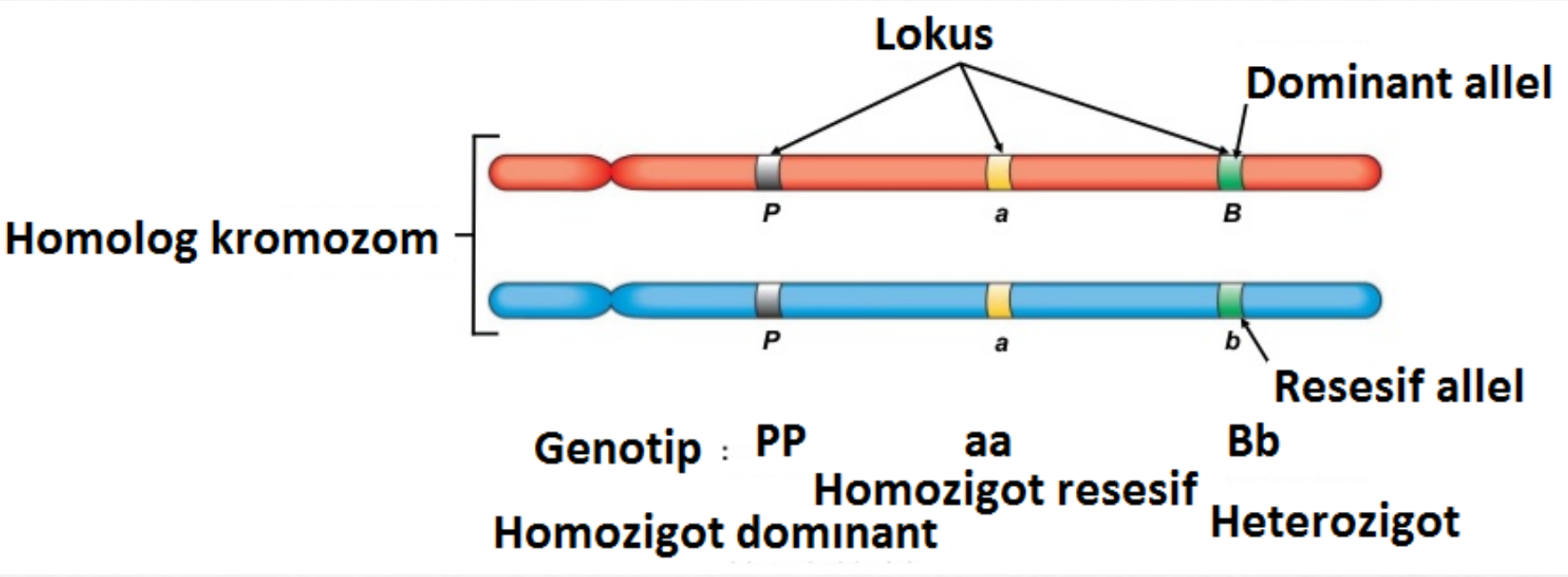
- **Phenotypic rate**

Aa +AA : aa ⟶ 3:1

- **Genotypic rate**

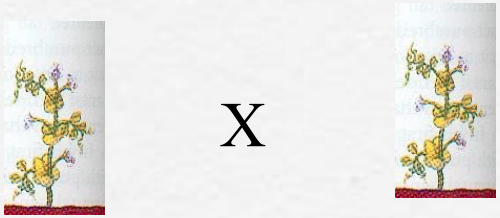
AA :Aa :Aa ⟶ 1:2:1




Lokus
Dominant allel
Homolog kromozom
P
a
B
P
a
b
Resesif allel
Genotip : PP aa Bb
Homozigot resesif
Homozigot dominant
Heterozigot

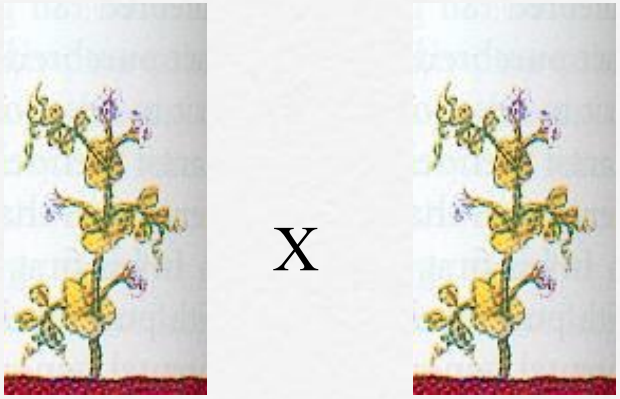
Mendel's Experiments

Mendel noticed that some plants always produced offspring that had a form of a trait exactly like the parent plant. He called these plants *"purebred"* plants. For instance, purebred short plants always produced short offspring and purebred tall plants always produced tall offspring.



Purebred Short Parents

Short Offspring



Purebred Tall Parents

Tall Offspring

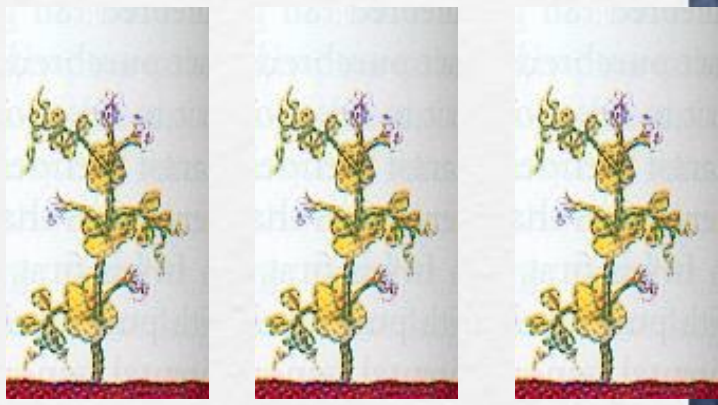
Mendel's First Experiment

Mendel crossed purebred plants with opposite forms of a trait. He called these plants the *parental generation* , or *P generation*. For instance, purebred tall plants were crossed with purebred short plants.

Parent Tall
P generation

X

Parent Short
P generation



Offspring Tall
F1 generation

Mendel observed that all of the offspring grew to be tall plants. None resembled the short parent. He called this generation of offspring the *first filial* , or *F1 generation,* (The word filial means "son" in Latin.)

Mendel's Experimental Results

Table 11.2 Ratios of Dominant to Recessive in Mendel's Plants

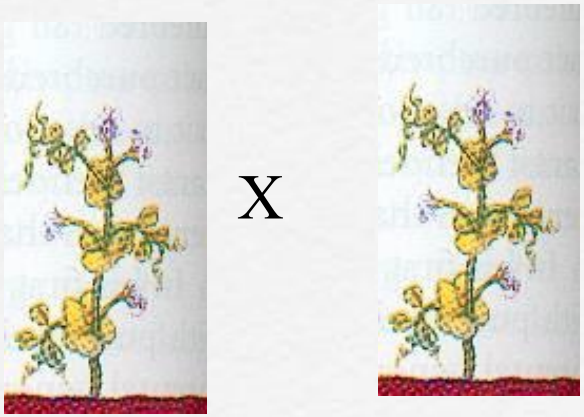
Dominant trait	Recessive trait	Ratio of dominant to recessive in F_2 generation
Smooth seed	Wrinkled seed	2.96:1 (5,474 smooth, 1,850 wrinkled)
Yellow seed	Green seed	3.01:1 (6,022 yellow, 2,001 green)
Inflated pod	Wrinkled pod	2.95:1 (882 inflated, 299 wrinkled)
Green pod	Yellow pod	2.82:1 (428 green, 152 yellow)
Purple flower	White flower	3.14:1 (705 purple, 224 white)
Flower on stem	Flower at tip	3.14:1 (651 along stem, 207 at tip)
Tall stem	Dwarf stem	2.84:1 (787 tall plants, 277 dwarfs)
	Average ratio, all traits:	**3:1**

due to statistical error

Mendel's Second Experiment

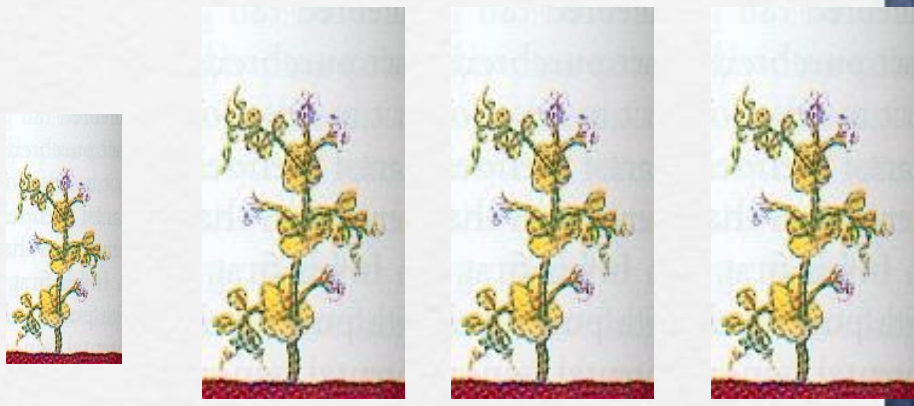
Mendel then crossed two of the offspring tall plants produced from his first experiment.

Parent Plants



Tall
F1 generation

Offspring



3⁄4 Tall & 1⁄4 Short
F2 generation

Mendel called this second generation of plants the second filial, F2, generation. To his surprise, Mendel observed that this generation had a mix of tall and short plants. This occurred even though none of the F1 parents were short.

Mendel's Conclusions

Mendel's first law, the *Law of Segregation*, has three parts. From his experiments, Mendel concluded that:

1. Plant traits are handed down through *"hereditary factors"* in the sperm and egg.

2. Because offspring obtain hereditary factors from both parents, each plant must contain two factors for every trait.

3. The factors in a pair segregate (separate) during the formation of sex cells, and each sperm or egg receives only one member of the pair.

Today, scientists refer to the "factors" that control traits as ***genes***. The different forms of a gene are called ***alleles***.

Alleles that mask or hide other alleles, such as the "tall" allele, are said to be ***dominant***.

A ***recessive*** *allele*, such as the short allele, is masked, or covered up, whenever the dominant allele is present.

Law of Segregation

- During the formation of gametes (eggs or sperm), the two alleles responsible for a trait separate from each other.
- The Principle of Segregation describes how pairs of gene variants are separated into reproductive cells.

Hybrid Alleles

In Mendel's first experiment, F1 offspring plants received one tall gene and one short gene from the parent plants. Therefore, all offspring contained both alleles, a short allele and a tall allele. When both alleles for a trait are present, the plant is said to be a hybrid for that trait. Today, we call hybrid alleles *heterozygous*.

short-short

X

tall-tall

short-tall

short-tall

Parent Short
P generation

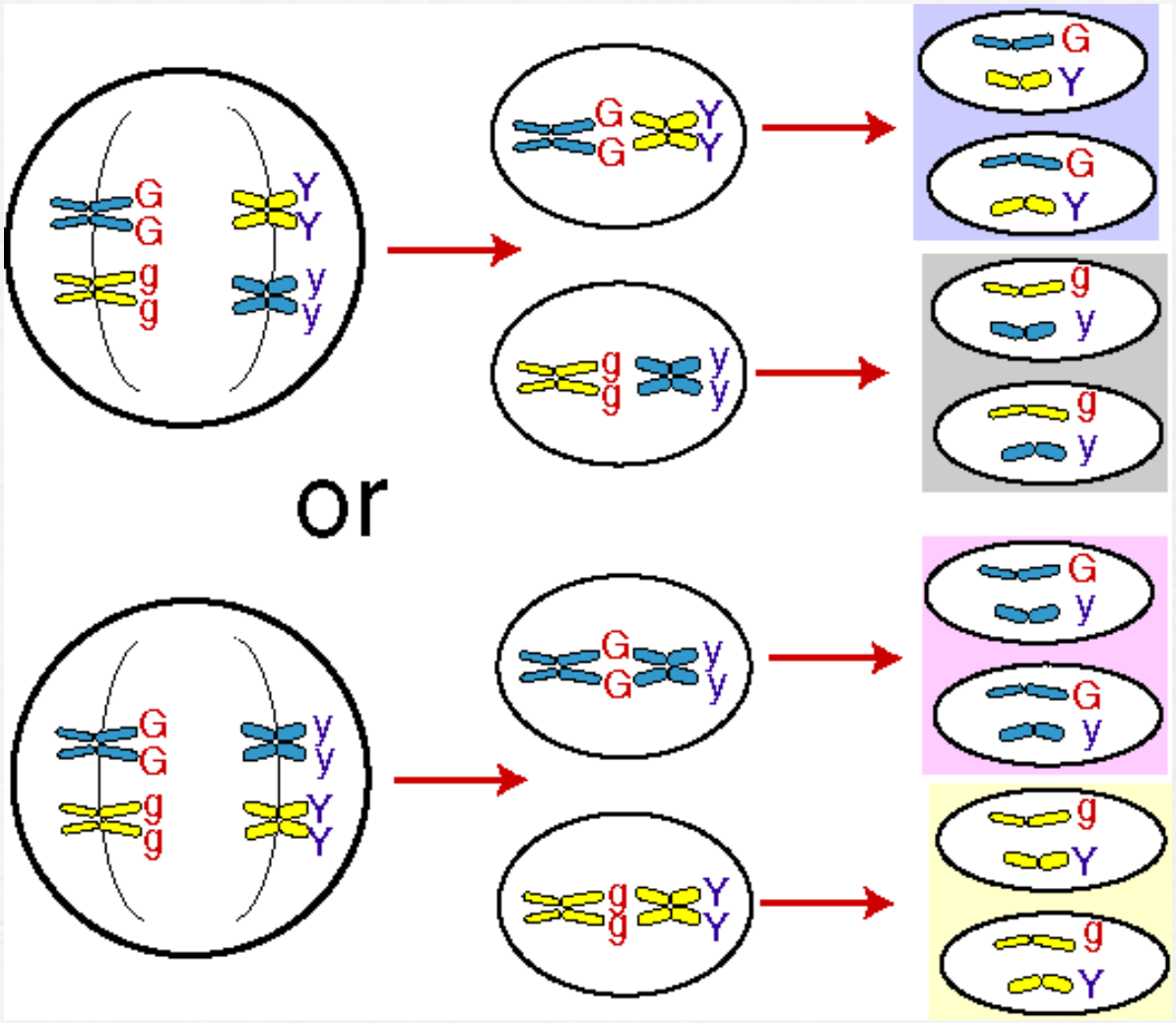
Parent Tall
P generation

Offspring Tall
F1 generation

Although the offspring have both a tall and a short allele, only the tall allele is expressed and is therefore dominant over short.

What if more there was more than one trait…

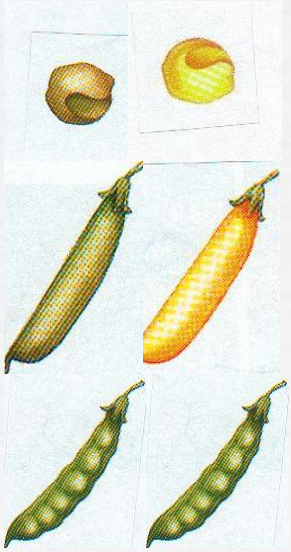
Dihybrid cross…



Two different alleles of the two different genes

Law of Independent Assortment

The Principle of Independent Assortment describes how different genes independently separate from one another when reproductive cells develop.

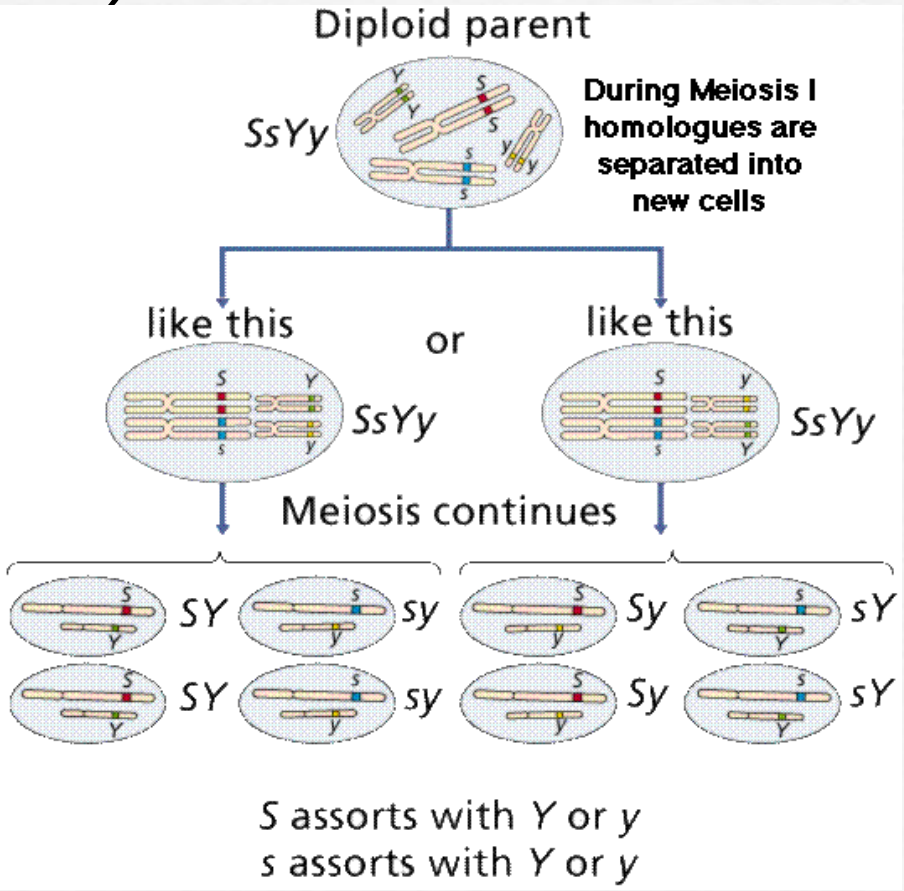


The donation of one allele from each pair is independent of any other pair.

For example, if the plant donates the yellow seed allele it does not mean that it will also donate the yellow pod allele.

Possible genotypes of the sperm or egg

Formula: 2^n (Where n is the number of heterozygous position of gene)



Question:

How many types of gametes are produced by an individual with the genotypes shown below ??

2^n

1. RrYy

2. AaBbCCDd

3. MmNnOoPPQQRrssTtQq

Answer:

1. RrYy: $2^n = 2^2 = 4$ gametes

   RY Ry rY ry

2. AaBbCCDd: $2^n = 2^3 = 8$ gametes

   ABCD ABCd AbCD AbCd

   aBCD aBCd abCD abCD

3. MmNnOoPPQQRrssTtQq: $2^n = 2^6 = 64$ gametes

- **Traits: seed shape & seed color**
- **Alleles: R smouth**
  r wrinkled
  Y yellow
  y green

RrYy x RrYy

Possible genotypes of the gametes?

Possible genotypes of F1?

- **Traits: seed shape & seed color**
- **Alleles: R smouth**
  r wrinkled
  Y yellow
  y green

RrYy x RrYy

RY Ry rY ry

RY Ry rY ry

Dihybrid cross

	RY	Ry	rY	ry
RY				
Ry				
rY				
ry				

	RY	Ry	rY	ry
RY	 RRYY	 RRYy	 RrYY	 RrYy
Ry	 RRYy	 RRyy	 RrYy	 Rryy
rY	 RrYY	 RrYy	 rrYY	 rrYy
ry	 RrYy	 Rryy	 rrYy	 rryy

9:3:3:1

Aa Bb

Aa Bb	AB	Ab	aB	ab
AB				
Ab				
aB				
ab				

POLYHYBRID CROSS

- It's when you cross more than one trait (usually more than 2 also, as 2 traits are a dihybrid cross)

AaBbCc X AaBbCc

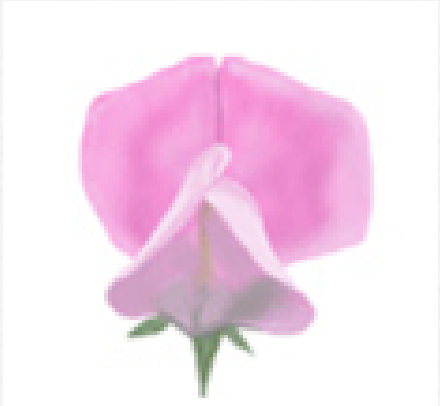
Possible genotypes of the gametes

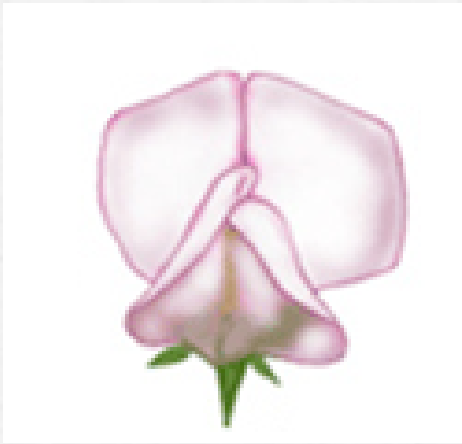
ABC Abc AbC aBC abC aBc Abc abc

	ABC	ABc	AbC	aBC	Abc	aBc	abC	abc
ABC	AABBCC	AABBCc	AABbCC	AaBBCC	AABbCc	AaBBCc	AaBbCC	AaBbCc
ABc	AABBCc	AABBcc	AABbCc	AaBbcc	AABbcc	AaBBcc	AaBbCc	AaBbcc
AbC	AAbBCC	AAbBCc	AAbbCC	AabBCC	AAbbCc	AabBCc	AabbCC	AabbCc
aBC	aABBCC	AaBBCc	aABbCC	aaBBCC	aABbCc	aaBBCc	aaBbCC	aaBbCc
Abc	AAbBcC	AAbBcc	AAbbcC	AabBcC	AAbbcc	AabBcc	AabbcC	Aabbcc
aBc	aABBcC	aABBcc	aABbcC	aaBBcC	aABbcc	aaBBcc	aaBbcC	aaBbcc
abC	aAbBCC	aAbBCc	aAbbCC	aabBCC	aAbbCc	aabBCc	aabbCC	aabbCc
abc	aAbBcC	aAbBcc	aAbbcC	aabBcC	aAbbcc	aabBcc	aabbcC	aabbcc

- How to determine the genotype of an individual with a dominant genotype?

P : purple
p : white

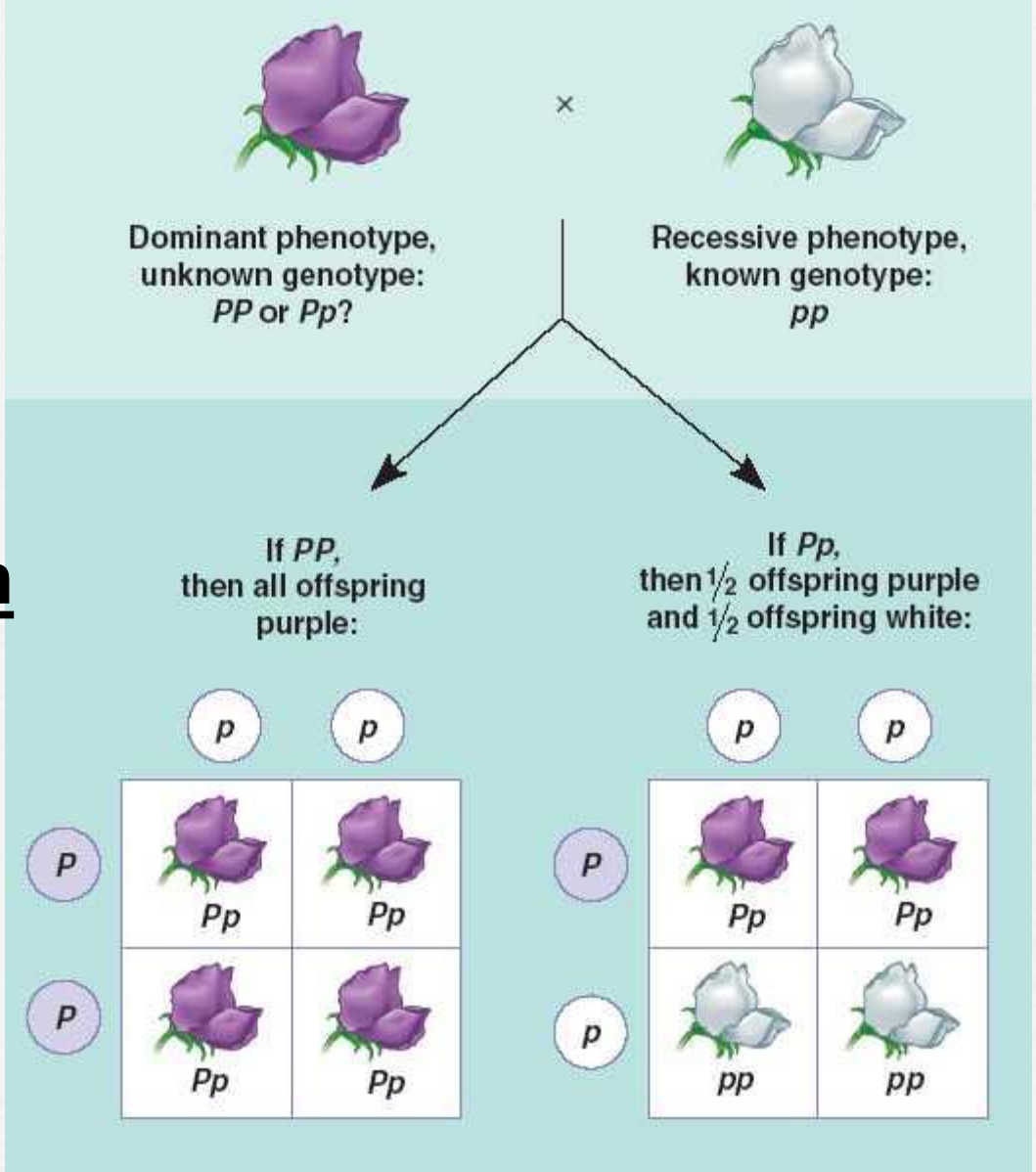




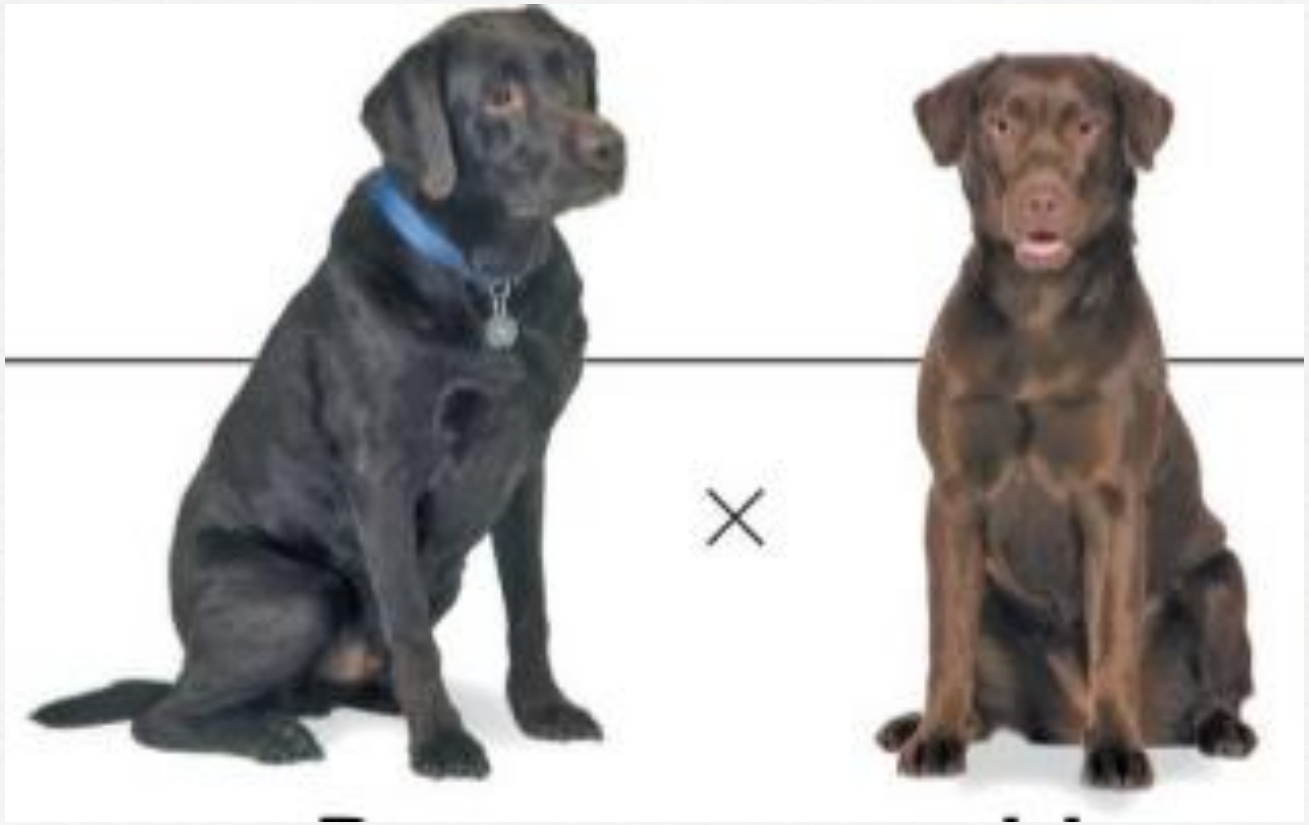
genotypes 

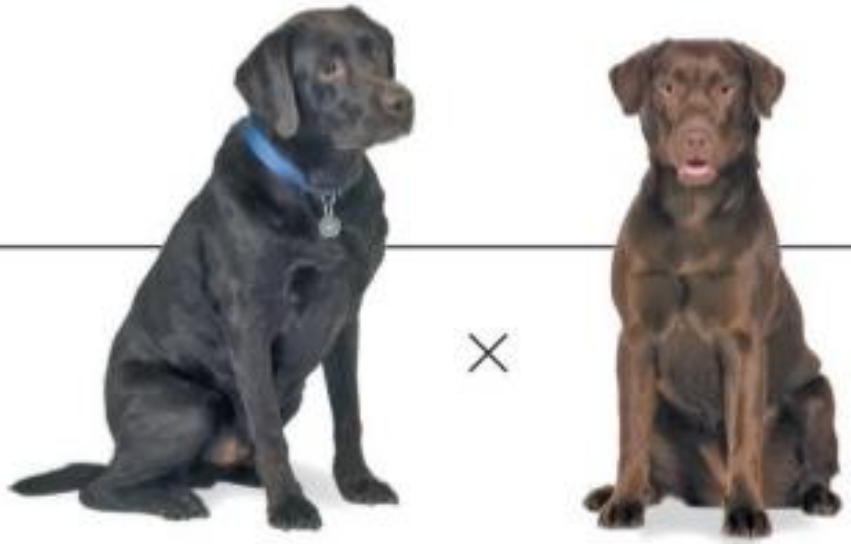
TEST CROSS

a genetic test for heterozygosity in which an organism of dominant phenotype, but unknown genotype, **is crossed to an organism recessive.**



- Black is dominant
- What are their genotypes?





Testcross

Genotypes *B_* × *bb*

Two possible genotypes for the black dog:

BB or *Bb*

Gametes: *B* | *b* and *B*

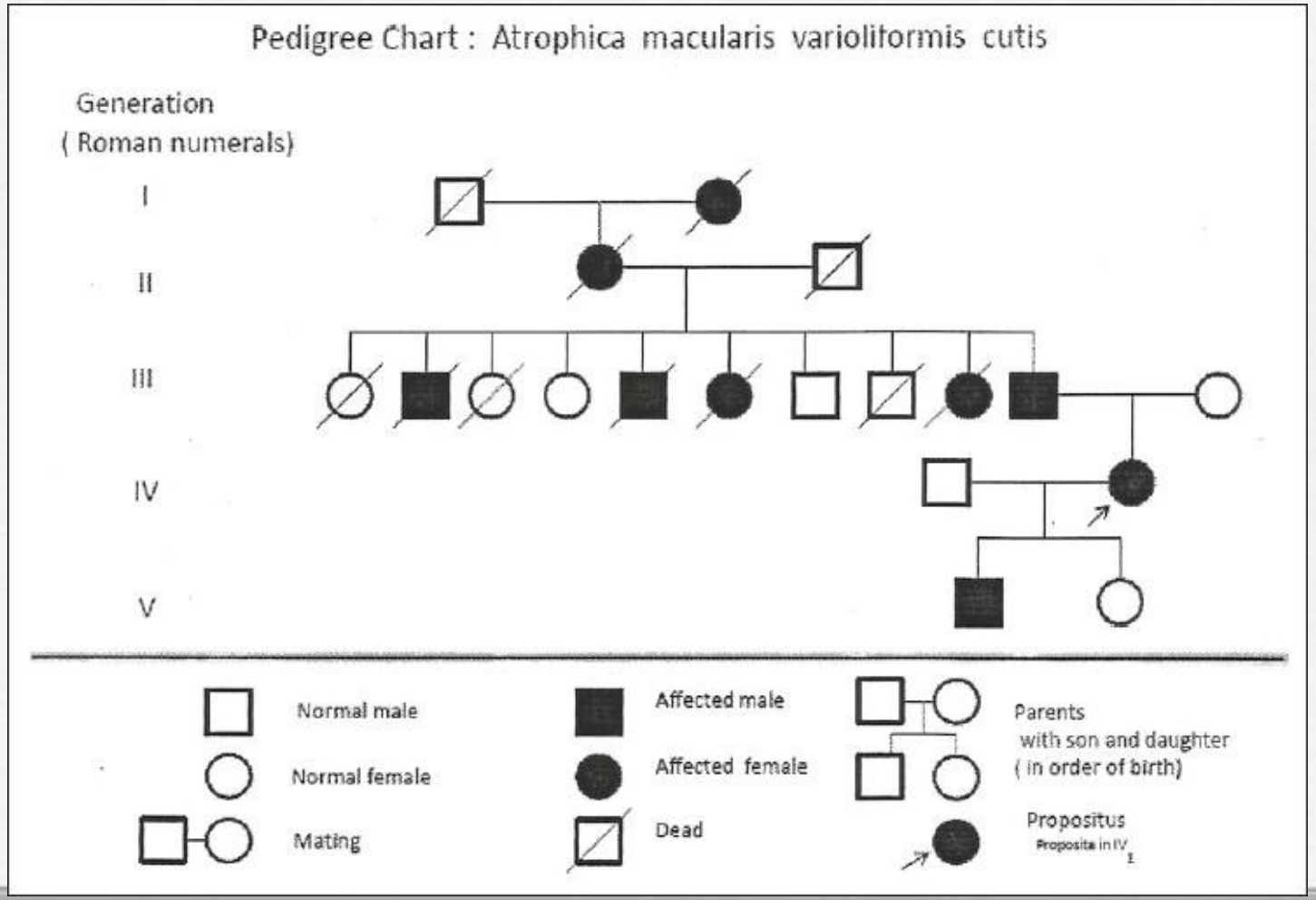
	B	*b*
b	*Bb*	

	B	*b*
b	*Bb*	*bb*

Offspring: All black | 1 black : 1 chocolate

PEDIGREE CHART

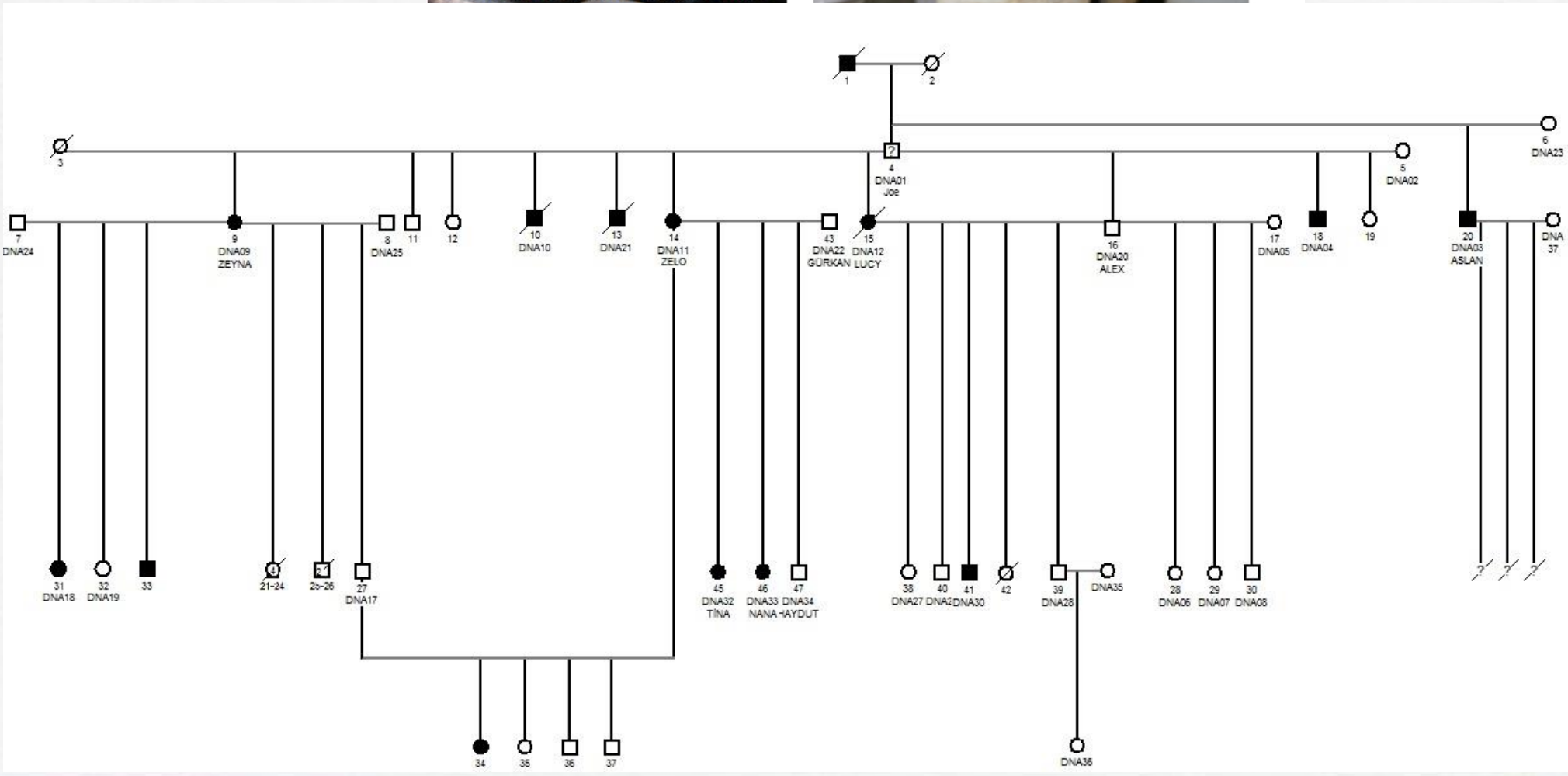
is a diagram that shows the occurrence and appearance or phenotypes of a particular gene or organism and its ancestors from one generation to the next



Example


photographed by Bengi ÇINAR KUL


photographed by Bengi ÇINAR KUL


1
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DNA01
Joe
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DNA02
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DNA23
7
DNA24
9
DNA09
ZEYNA
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DNA25
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12
10
DNA10
13
DNA21
14
DNA11
ZELO
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DNA22
GÜRKAN
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DNA12
LUCY
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ALEX
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