SNS COLLEGE OF ENGINEERING

Kurumbapalayam (Po), Coimbatore – 641 107

An Autonomous Institution

Accredited by NBA – AICTE and Accredited by NAAC – UGC with 'A' Grade

Approved by AICTE, New Delhi & Affiliated to Anna University, Chennai

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

Subject Code: 19BY701

Subject: Biology for Engineers

Unit-III

Topic: Genetics/ Mendels law of Inheritance

INTRODUCTION

Course Objective

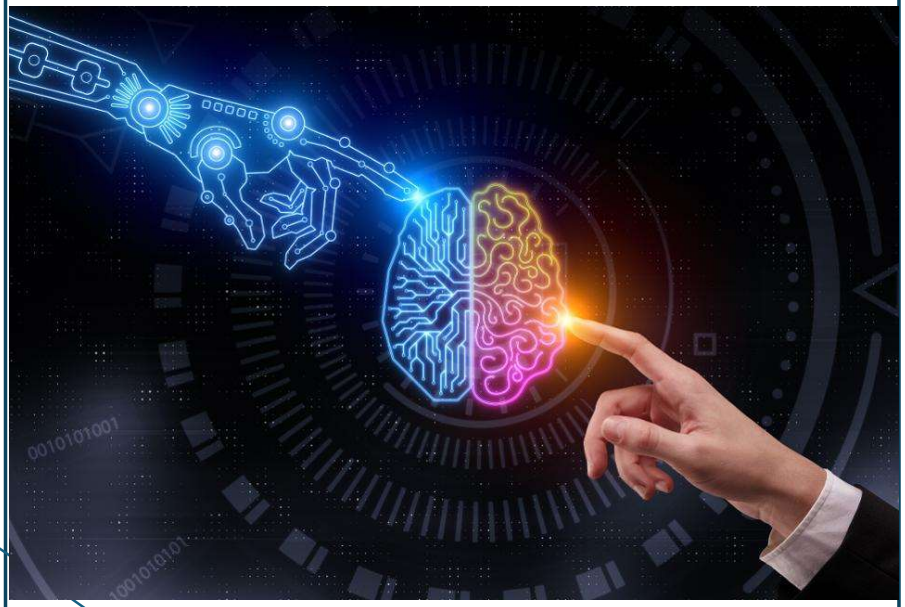
- This subject is designed to impart fundamental knowledge on basic of genetics and emerging fields of biology like biomedical recording system and medical instrumentation.
- It is designed to impart knowledge that how to apply basics of biology in engineering.

https://www.uic.es/sites/default/files/uic-grau-bioenginyeria-hero-header_1.jpg

INTRODUCTION

Course Outcome

CO Number	Title	Level
CO1	Identify the biological concepts from an engineering perspective.	**knowledge**
CO2	Development of artificial systems mimicking human action.	**Understand**
CO3	Explain the basic of genetics that helps to identify and formulate problems	Analyze
CO4	Apply knowledge of measurement system, biomedical recording system and biosensors to excel in areas such as entrepreneurship, medicine, government, and education.	Apply
CO5	Integrate biological principles for developing next generation technologies,	Create



Will be covered in this lecture

https://specials-images.forbesimg.com/imageserve/1034901762/960x0.jpg?fit=scale

Genetics

Mendel’s Laws of Inheritance

Genetics

- **What is genetics?**
  - "Genetics is the study of **heredity**, the process in which a parent passes certain **genes** onto their children."
- **What does that mean?**
  - Children **inherit** their biological parents' genes that express specific **traits**, such as some physical characteristics, natural talents, and genetic disorders.

Genetic Concepts

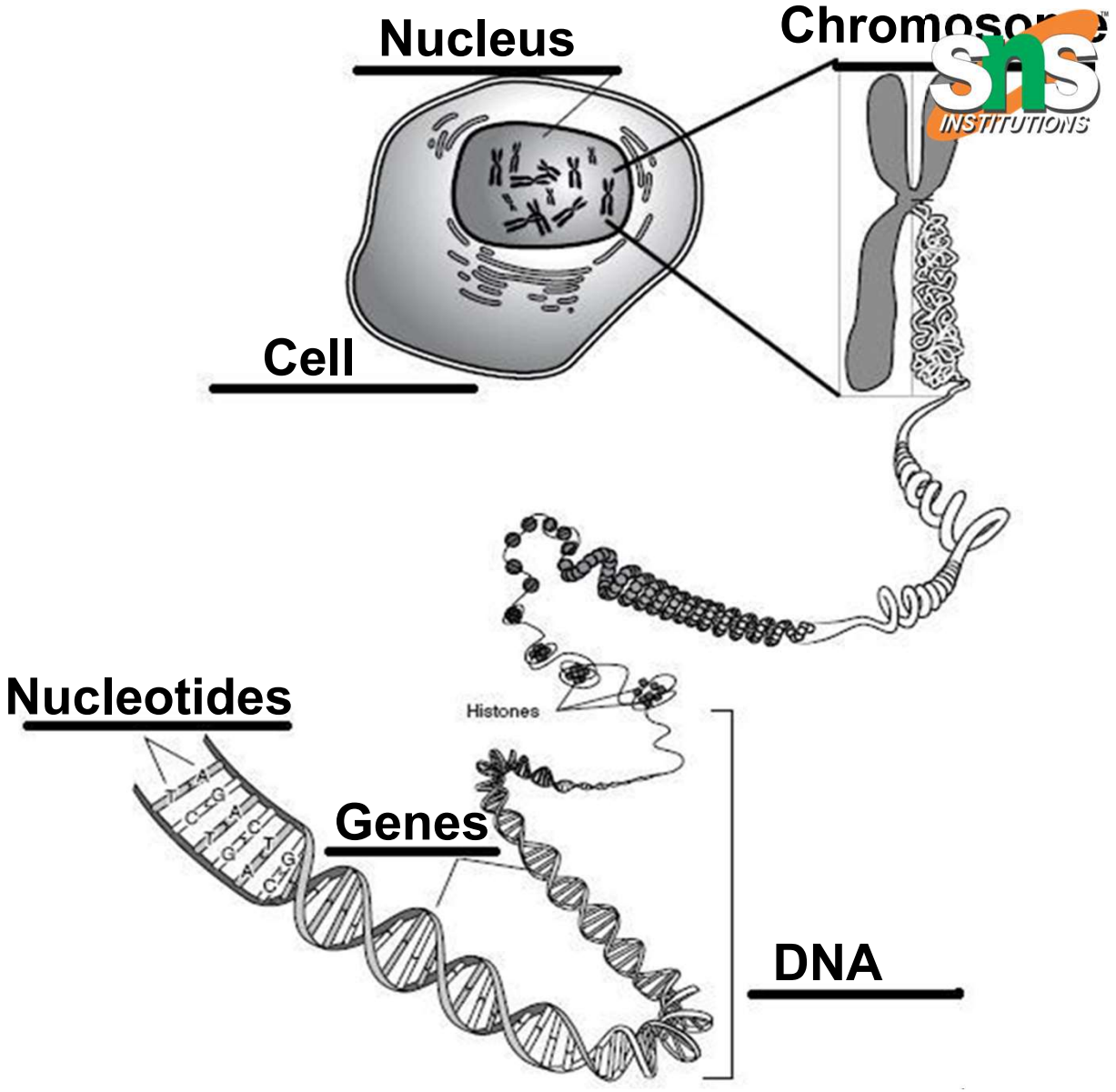
- **Heredity** describes how some traits are passed from parents to their children.
- The traits are expressed by **genes**, which are small sections of DNA that are coded for specific traits.
- Genes are found on **chromosomes**.
  - Humans have two sets of **23** chromosomes—one set from each parent.

is the "instruction code" that the genes use to form traits.

- DNA is long threads of material found in all cells.
- DNA contains the "master code" that instructs all cells in their daily jobs.

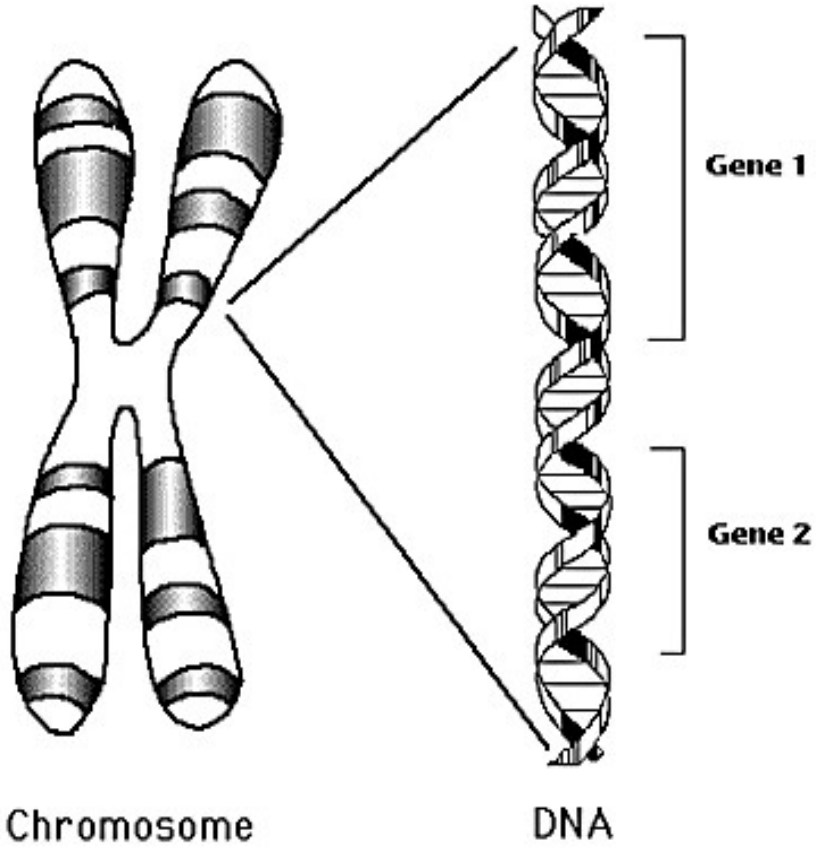
Genes are short pieces of DNA that make up our chromosomes.

Each piece of DNA that is related to a gene makes up one trait.



Concept of Traits, Genes, and Alleles

- Genes influence the development of traits
  - All of an organism's genetic material is called the genome.
  - A genotype refers to the makeup of a specific set of genes.
  - A phenotype is the physical expression of a trait.

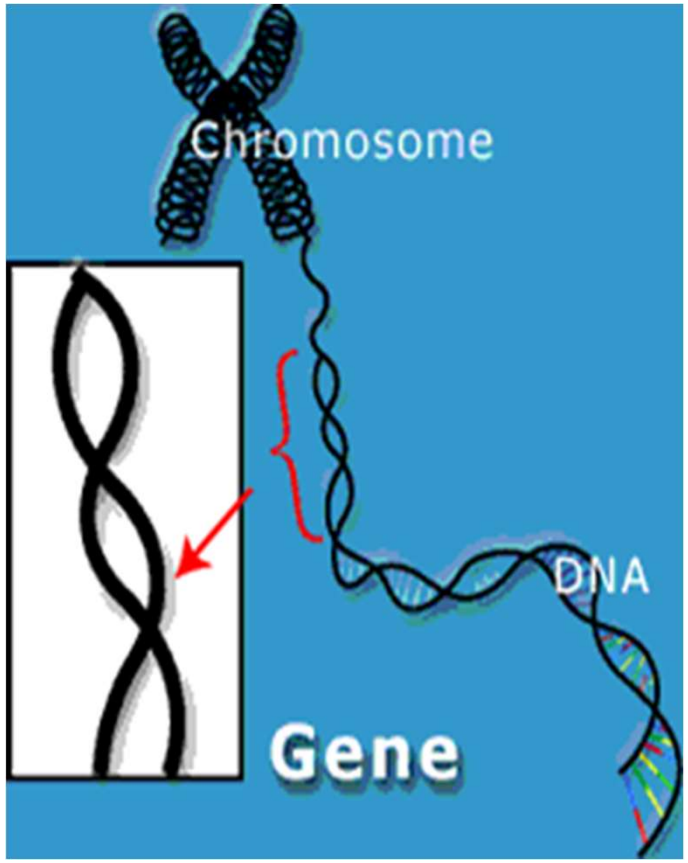


Concept of Traits, Genes, and Alleles

- What is a Trait?
  - A trait is a specific characteristic that is unique.
  - Traits affect the way we look
  - Traits affect how our bodies function
  - Traits are inherited
    - Examples are hair color, eye color, handedness, etc.

Genetics terms you need to know:

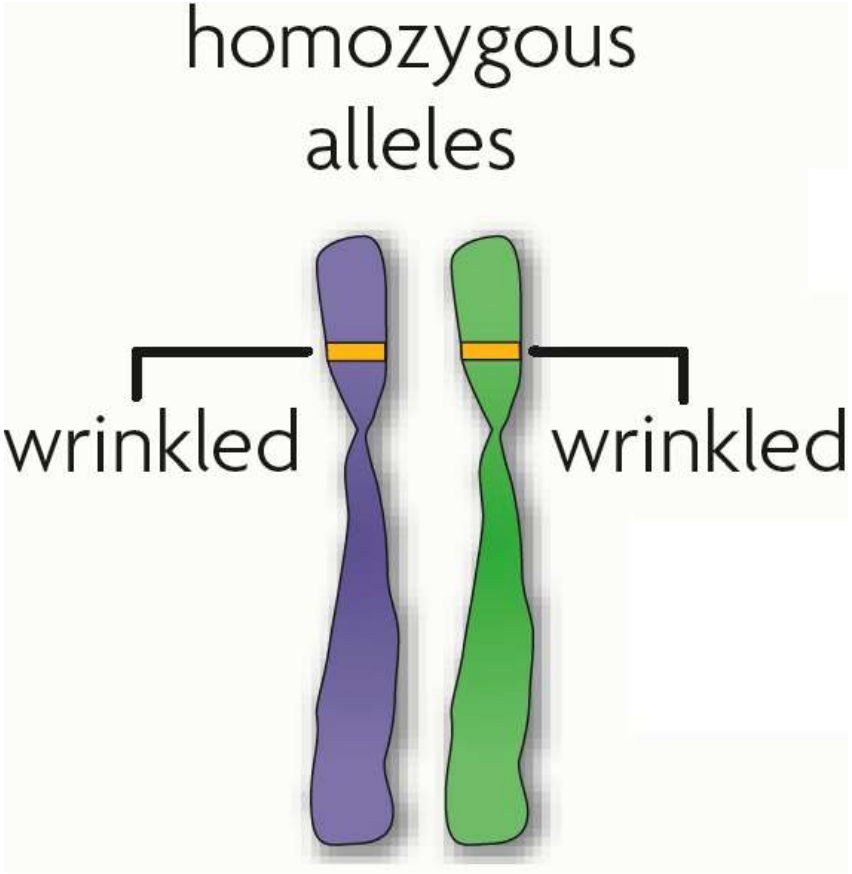
- **Gene** – a unit of heredity; a section of the DNA sequence encoding a single protein
- **Genome** – the entire set of genes in an organism
- **Alleles** – two genes that occupy the same position on homologous chromosomes and that cover the same trait (like 'flavors' of a trait).
- **Locus** – a fixed location on a strand of DNA where a gene or one of its alleles is located.



- **Homozygous** – having identical alleles of a gene (one from each parent) for a particular characteristic.
- **Heterozygous** – having two different alleles of a gene for a particular characteristic.
- **Dominant** – the allele of a gene that masks or suppresses the expression of an alternate allele; the trait appears in the heterozygous condition.
- **Recessive** – an allele that is masked by a dominant allele; does not appear in the heterozygous condition, only in homozygous.
- **Genotype** – the genetic makeup of an organisms
- **Phenotype** – the physical appearance of an organism (Genotype + environment)

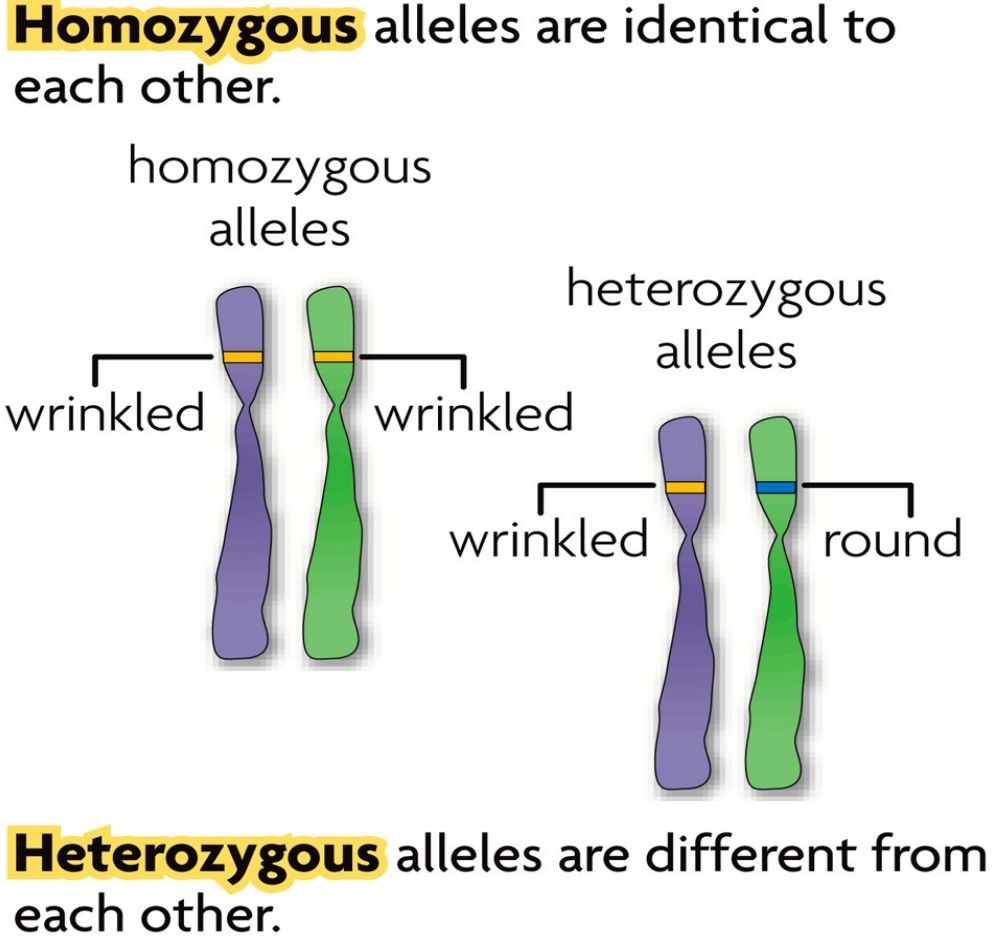
Concept of Traits, Genes, and Alleles

- The same gene can have many versions:
  - A gene is a piece of DNA that directs a cell to make a certain protein.
  - Each gene has a locus, a specific position on a pair of homologous chromosomes.



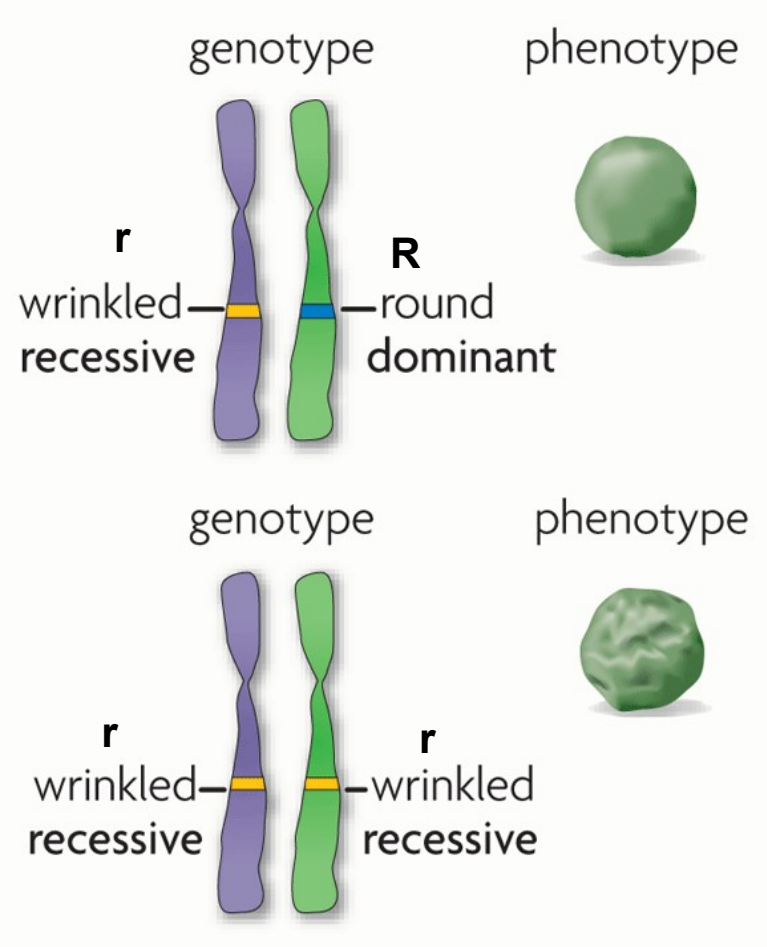
Concept of Traits, Genes, and Alleles

- An allele is any alternative form of a gene occurring at a specific locus on a chromosome
  - Each parent donates one allele for every gene.
  - Homozygous describes two alleles that are the same at a specific locus.
  - Heterozygous describes two alleles that are different at a specific locus.



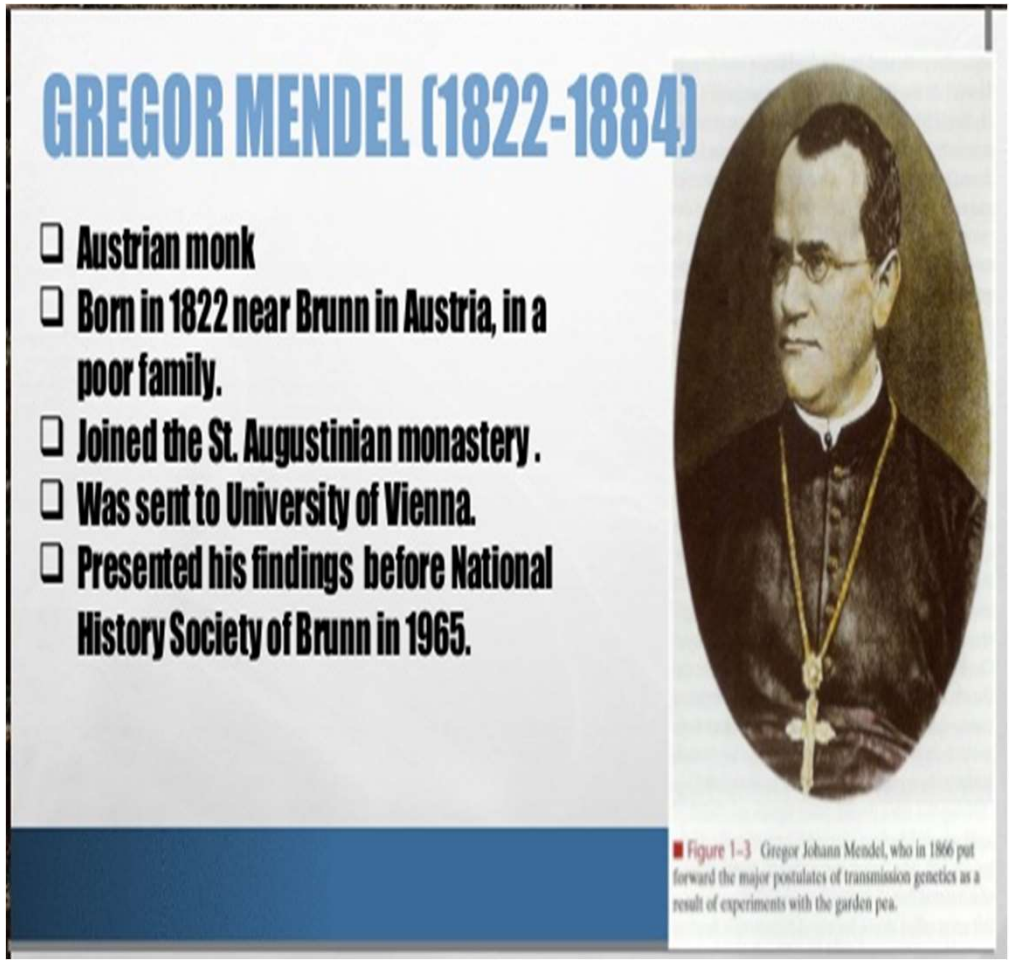
Concept of Traits, Genes, and Alleles

- Alleles can be represented using letters
  - A dominant allele is expressed as a phenotype when at least one allele is dominant.
  - A recessive allele is expressed as a phenotype only when two copies are present.
  - Dominant alleles are represented by uppercase letters; recessive alleles by lowercase letters.
  - Both homozygous dominant and heterozygous genotypes yield a dominant phenotype.
  - Most traits occur in a range and do not follow simple dominant-recessive patterns.

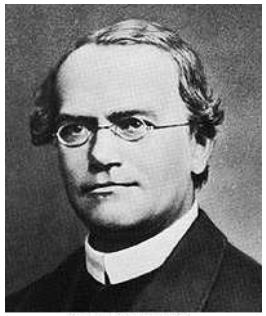


History

- Genetics began with the work of Gregor Mendel.
- Gregor developed basic principles of heredity without ANY scientific equipment and NO knowledge of genes or chromosomes - only his mind!
- Gregor experimented with pea plants, by crossing various strains and observing the characteristics of their offspring.



Gregor Johann Mendel


Gregor Mendel

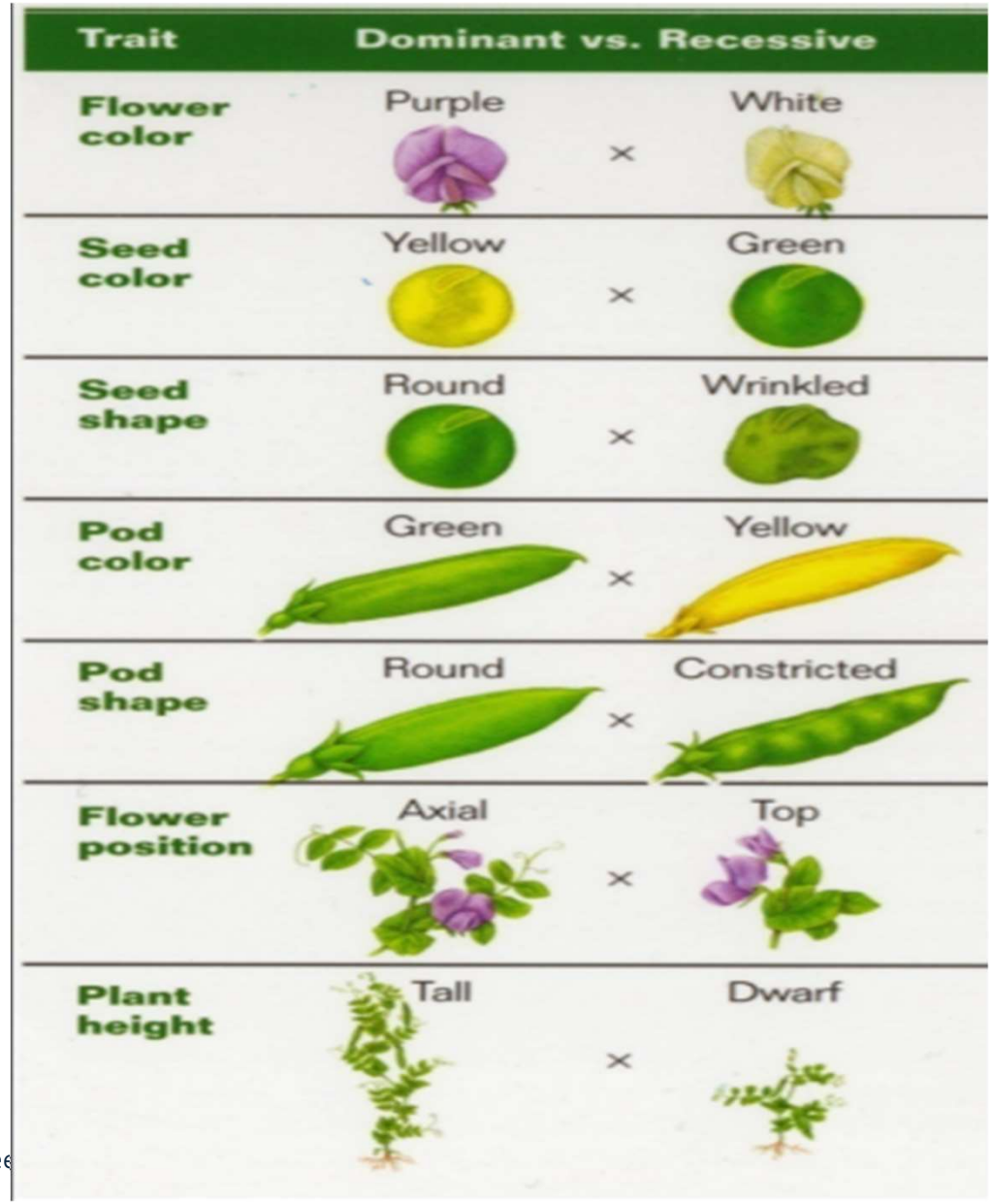
- Austrian Monk, born in what is now Czech Republic in 1822
- Son of peasant farmer, studied Theology and was ordained priest Order St. Augustine.
- Went to the university of Vienna, where he studied botany and learned the Scientific Method
- Worked with pure lines of peas for eight years
- In 1866 he published *Experiments in Plant Hybridization*, (*Versuche über Pflanzen-Hybriden*) in which he established his three Principles of Inheritance
- Work was largely ignored for 34 years, until 1900, when 3 independent botanists rediscovered Mendel's work.
- Prior to Mendel work, heredity was regarded as a "blending" process and the offspring were essentially a "dilution" of the different parental characteristics.

Mendel's peas

- Mendel looked at seven traits or characteristics of pea plants:

7 Characteristics in Peas

Trait	Stem length	Pod shape	Seed shape	Seed color	Flower position	Flower color	Pod color
Characteristics	Tall	Inflated	Smooth	Yellow	Lateral	Purple	Green
	Dwarf	Constricted	Wrinkled	Green	Terminal	White	Yellow



Mendel Experimental Material

- **He selected the garden pea plant as a sample for the following reasons:**

I. Pea is available in many varieties on a large scale to observe alternate traits.

II. Peas are self-pollinated and can be cross-pollinated also to prevent self-pollination.

III. These are annual plants with a short life cycle. So, several generations can be studied within a short period.

IV. Pea plants could easily be raised, maintained and handled.

- Mendel was the first biologist to use Mathematics – to explain his results quantitatively.

- Mendel predicted
  - The concept of genes
  - That genes occur in pairs
  - That one gene of each pair is present in the gamet

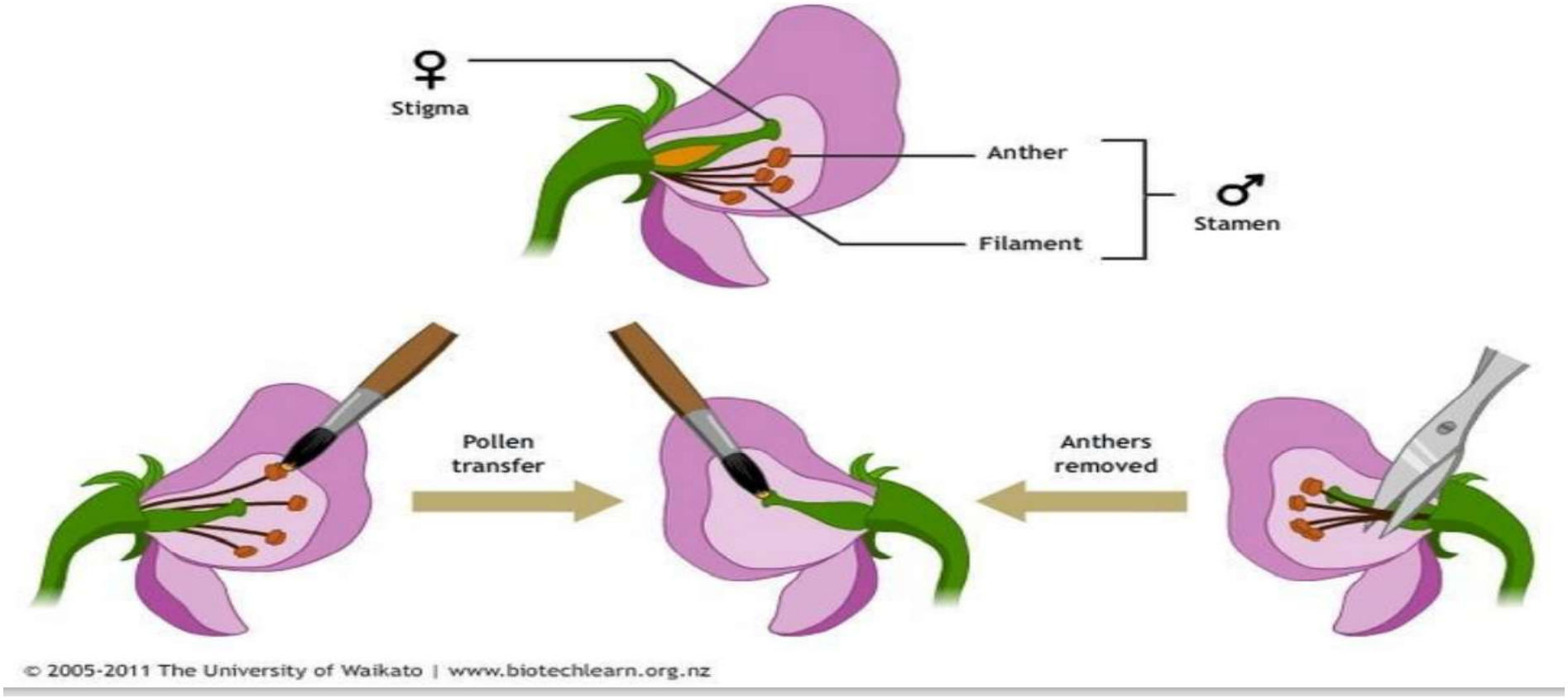
Mendel Developed Principles of:

- **Dominance**: one form of a hereditary trait dominates or prevents the expression of the recessive trait.
- **Segregation**: Splitting of chromosomes during meiosis
- **Recombination**: Combining chromosomes from both the sperm and egg (fertilization)
- **Independent Assortment:** Independent segregation of genes during the formation of gametes.

Pea Plan T Characteristics

- Mendel determined that since peas reproduce sexually, there must be two “characters” (called alleles) that influence each trait (one from the egg and one from the pollen).
- Alleles are represented by letters.

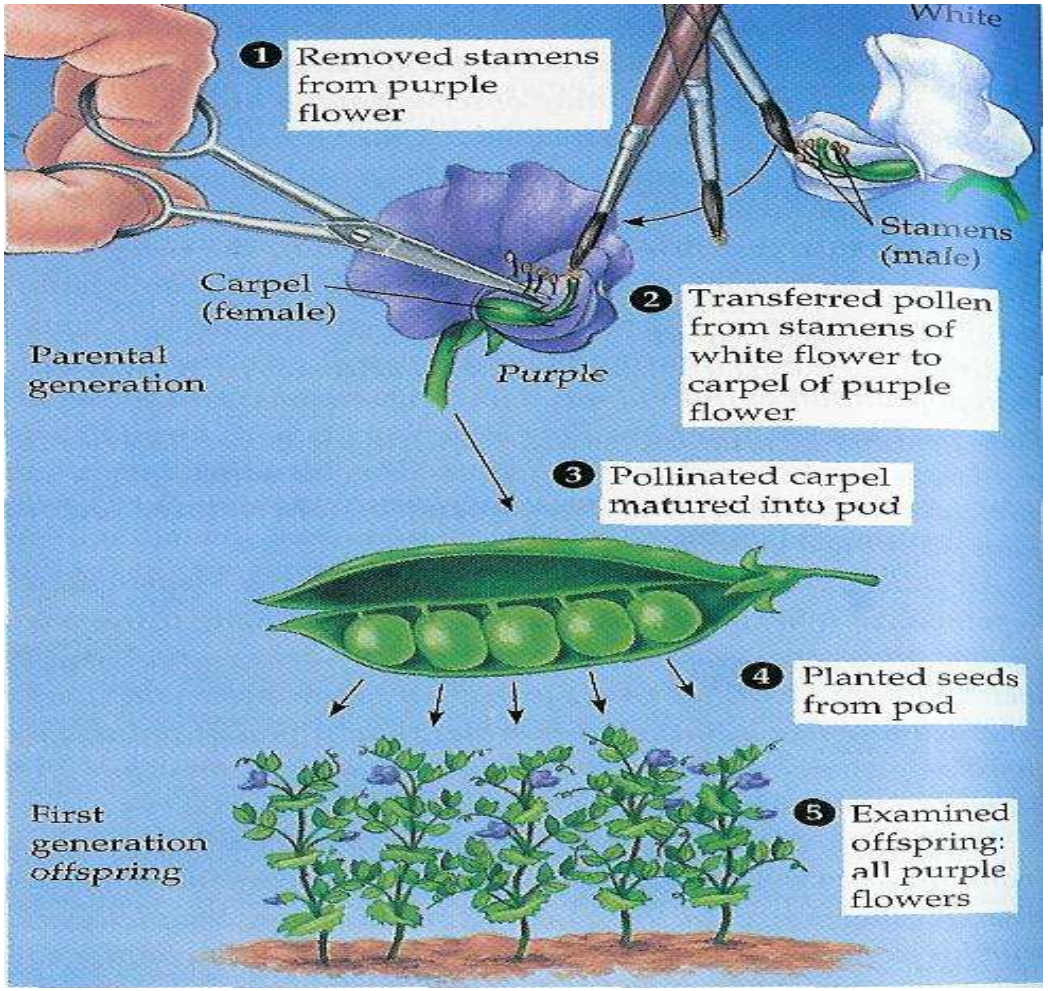
Working with Pea Plants – The Next Generation



Genetic crosses

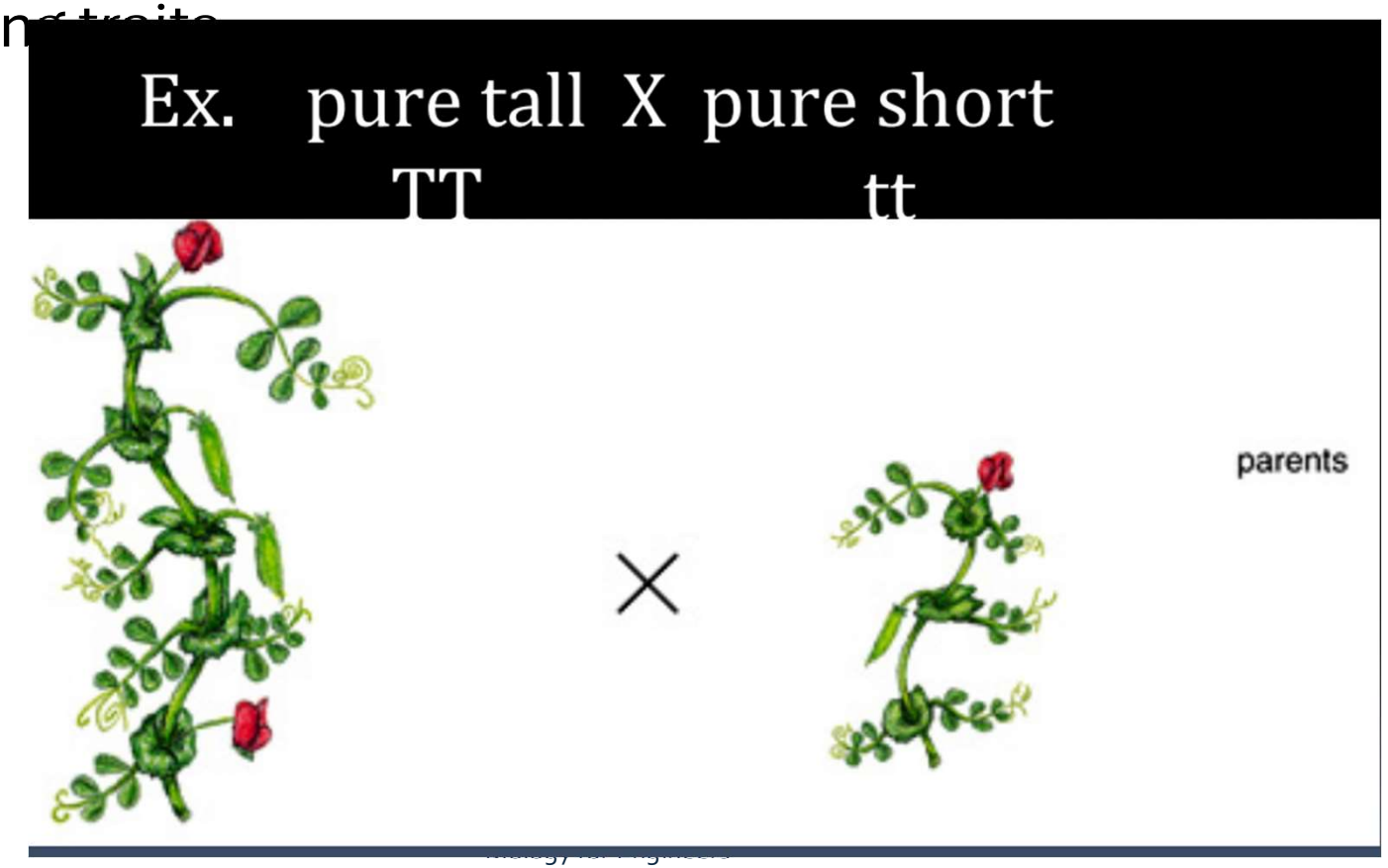
- To cross two different pea plants, Mendel used an artist's brush.

- He transferred pollen from a true breeding white flower to the carpel of a true breeding purple flower.



Mendel's Work

- Mendel began by cross-pollinating pure plants with contrasting traits

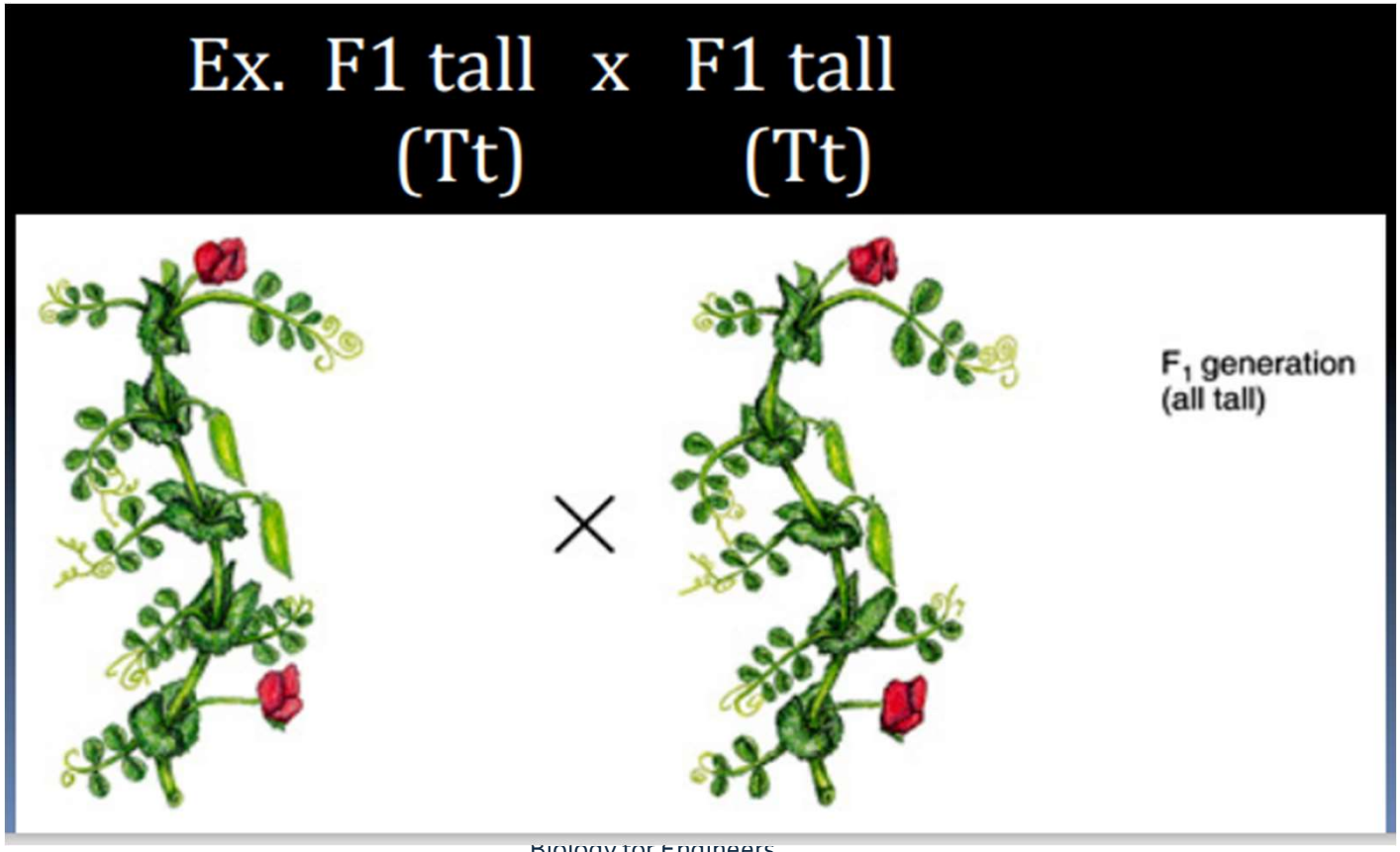


Mendel's Work

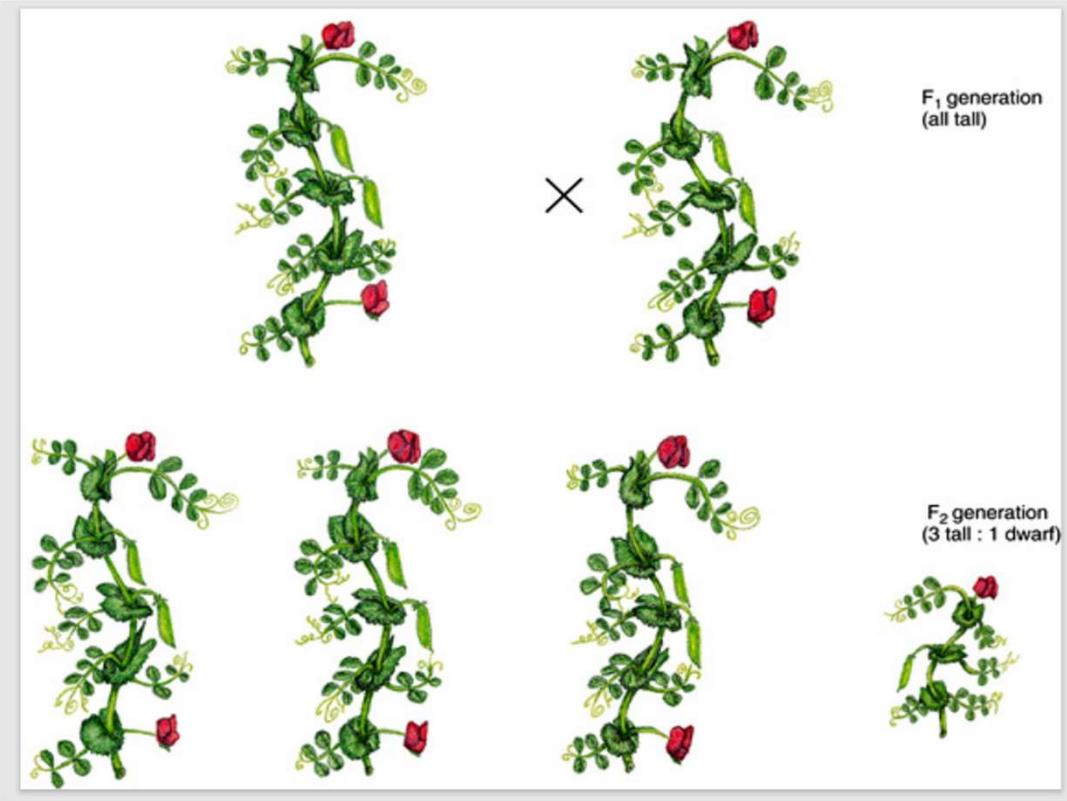
- Mendel then observed the offspring or 1st Filial generation (F1), and noticed only one trait (they were all tall)

Mendel's Work

- Mendel then used two of these F1 tall plants and crossed them.



- From this F1 cross he observed both traits in the offspring (2nd Filial generation–F2), but in an unequal proportion (75% tall and 25% short) or (3 tall : 1 short)



Mendel's Work

- Mendel determined that one form of the trait is dominant over the other recessive trait (Tall is dominant over short)

Parents	pure tall	X	pure short
F1	all tall		
F2	3 tall	:	1 short

Law of Dominance

- According to this law
  - Characters are controlled by discrete units called factors
  - Factors occur in pairs
  - In a dissimilar pair of factors (heterozygous) one member of the pair dominates the other
- It is because of law of dominance only one parental character expresses itself in the F1 generation while both are expressed in F2 generation.

Law of Dominance – one form of a hereditary trait dominates or prevents the expression of the recessive trait.

Dominant allele = capital letter
Recessive allele = lower case letter

Ex. tall = T
short = t

- Parents have 2 alleles (2n) Diploid
- Gametes have 1 allele (1n) Monoploid
  - (half due to meiosis)

Review of dominance :

TT = tall
Tt = tall
tt = short

Law of Segregation

- According to this law parents contain two alleles during gamete formation, the factors or alleles of pair segregate from each other such that a gamete receives only one of the two factors.

- A homozygous parent produces all gametes that are similar while a heterozygous one, produces two kinds of gametes each having one allele with equal proportion

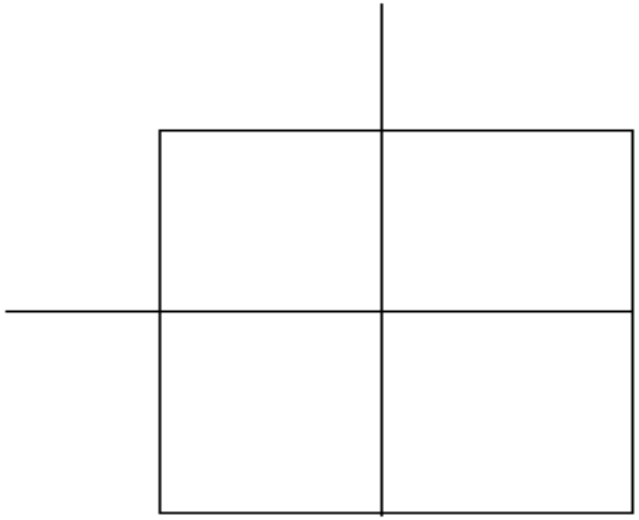
Monohybrid cross
(cross with only 1 trait)

- Problem
  - Using this is a several step process, look at the following example
    - Tallness (T) is dominant over shortness (t) in pea plants.
    - A Homozygous tall plant (TT) is crossed with a short plant (tt).
    - What is the genotypic makeup of the offspring? The phenotypic makeup?

Punnett Squares

- Genetic problems can be easily solved using a tool called a Punnett square.
  - Tool for calculating genetic probabilities

A Punnett square



Punnett Squares Vocabulary

- **Punnett Squares**: The chart used to show the possible ways genes are combined when passed from parents to offspring.
- **Dominant genes are UPPER CASE (T)**
- **Recessive genes are lower case (t)**
- **Each parent has two genes for a trait. (TT), (Tt) or (tt).**
- **There can be a possible four combinations for each cross.**

Punnett Squares Vocabulary

GENOTYPE: The gene combination

- **Homozygous**– Pure dominate or pure recessive
- **Heterozygous**– Hybrid a mixed

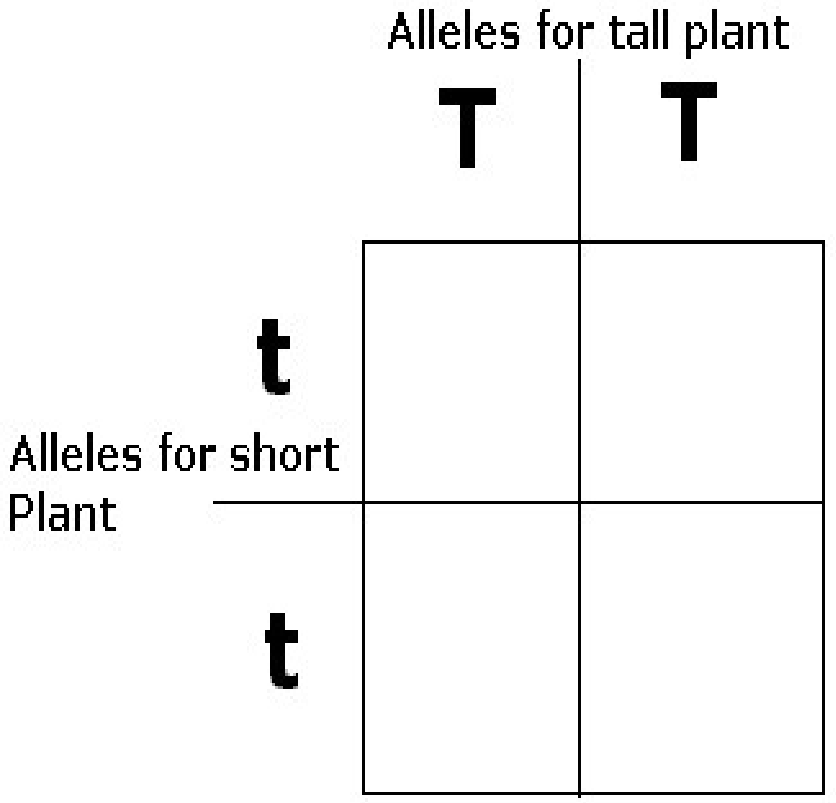
PHEOTYPE :The physical appearance

- **Dominate trait**
- **Recessive trait**
- **Combination of two traits (incomplete dominance)**

Punnett process

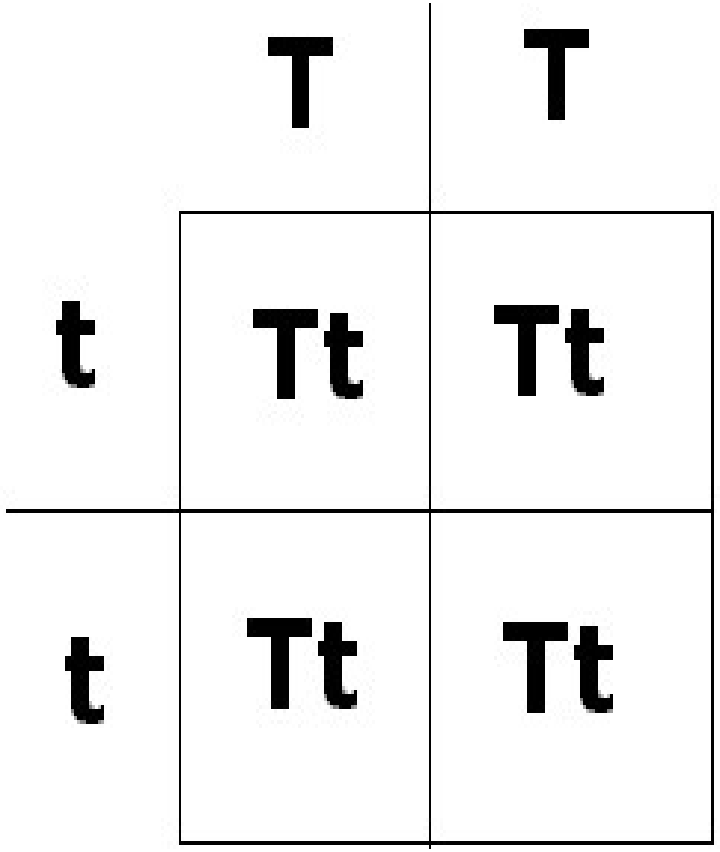
1) Determine alleles of each parent, these are given as TT, and tt respectively.

2) Take each possible allele of each parent, separate them, and place each allele either along the top, or along the side of the Punnett square.



Punnett process continued

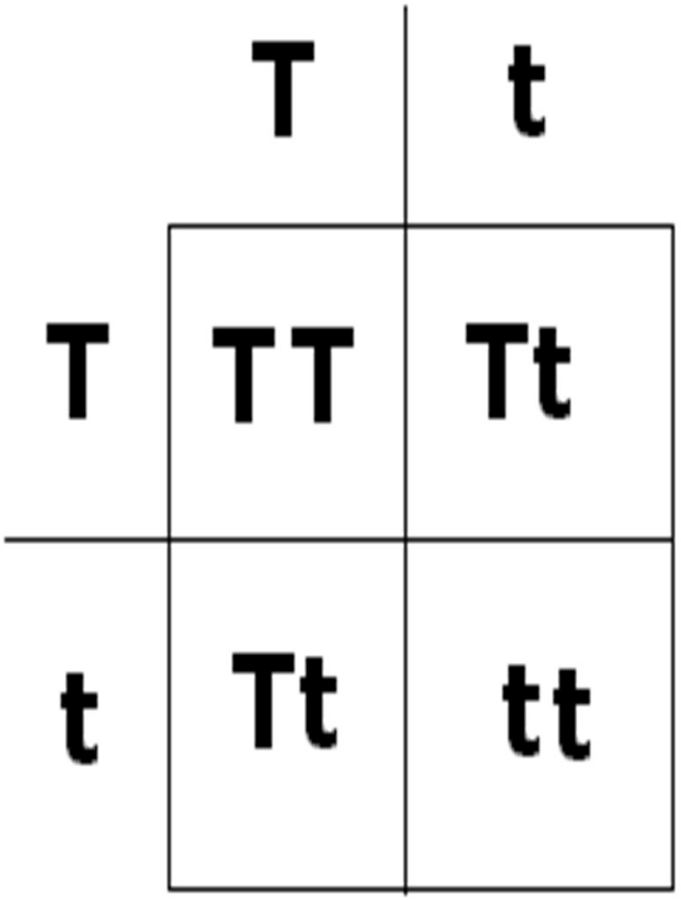
- Lastly, write the letter for each allele across each column or down each row.
- The resultant mix is the genotype for the offspring (F1 generation).
- In this case, each offspring has a Tt (heterozygous tall) genotype, and simply a "Tall" phenotype.



F1 Generation

Punnett process

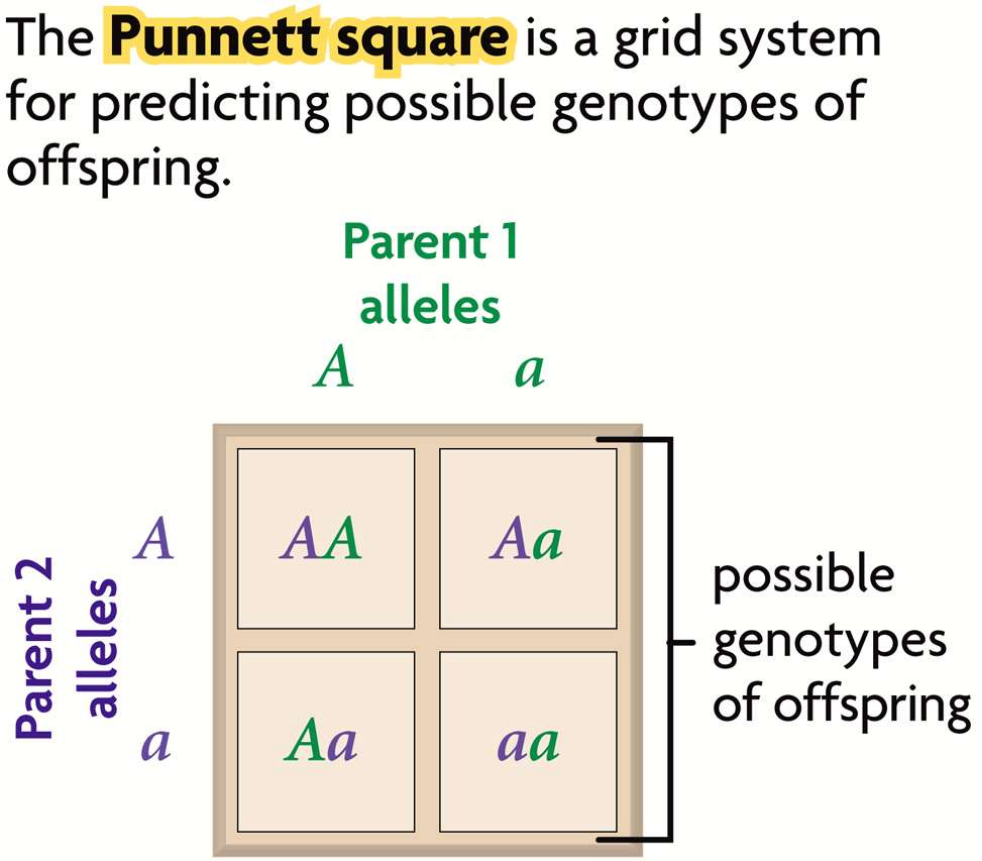
- Here we have some more interesting results: First we now have 3 genotypes (TT, Tt, & tt) in a 1:2:1 **genotypic ratio**.
- We now have 2 different phenotypes (Tall & short) in a 3:1 **Phenotypic ratio**.
- This is the common outcome from such crosses.



F2 Generation

Punnett squares illustrate genetic crosses

- The Punnett square is a grid system for predicting all possible genotypes resulting from a cross.
  - The axes represent the possible gametes of each parent.
  - The boxes show the possible genotypes of the offspring.
- The Punnett square yields the ratio of possible genotypes and phenotypes.



Each true-breeding plant of the parental generation has identical alleles, *PP* or *pp*.

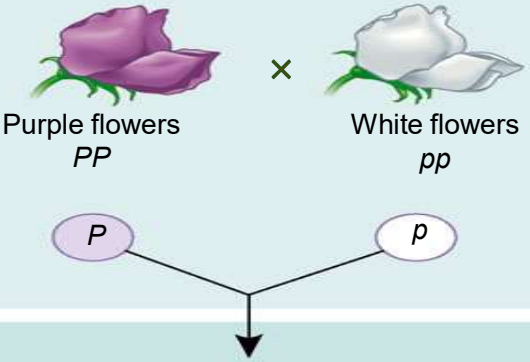
Gametes (circles) each contain only one allele for the flower-color gene.

In this case, every gamete produced by one parent has the same allele.

P Generation

Appearance:
Genetic makeup:

Gametes:



Union of the parental gametes produces F_1 hybrids having a *Pp* combination.

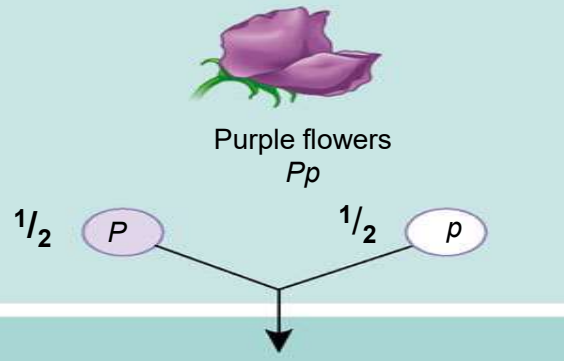
Because the purple-flower allele is dominant, all these hybrids have purple flowers.

When the hybrid plants produce gametes, the two alleles segregate, half the gametes receiving the *P* allele and the other half the *p* allele.

F_1 Generation

Appearance:
Genetic makeup:

Gametes:



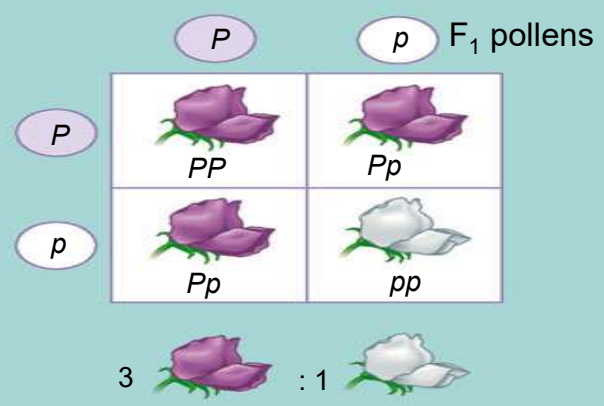
This box, a Punnett square, shows all possible combinations of alleles in offspring that result from an $F_1 \times F_1$ (*Pp* × *Pp*) cross. Each square represents an equally probable product of fertilization.

For example, the bottom left box shows the genetic combination resulting from a *p* egg fertilized by a *P* sperm.

Random combination of the gametes results in the 3:1 ratio that Mendel observed in the F_2 generation.

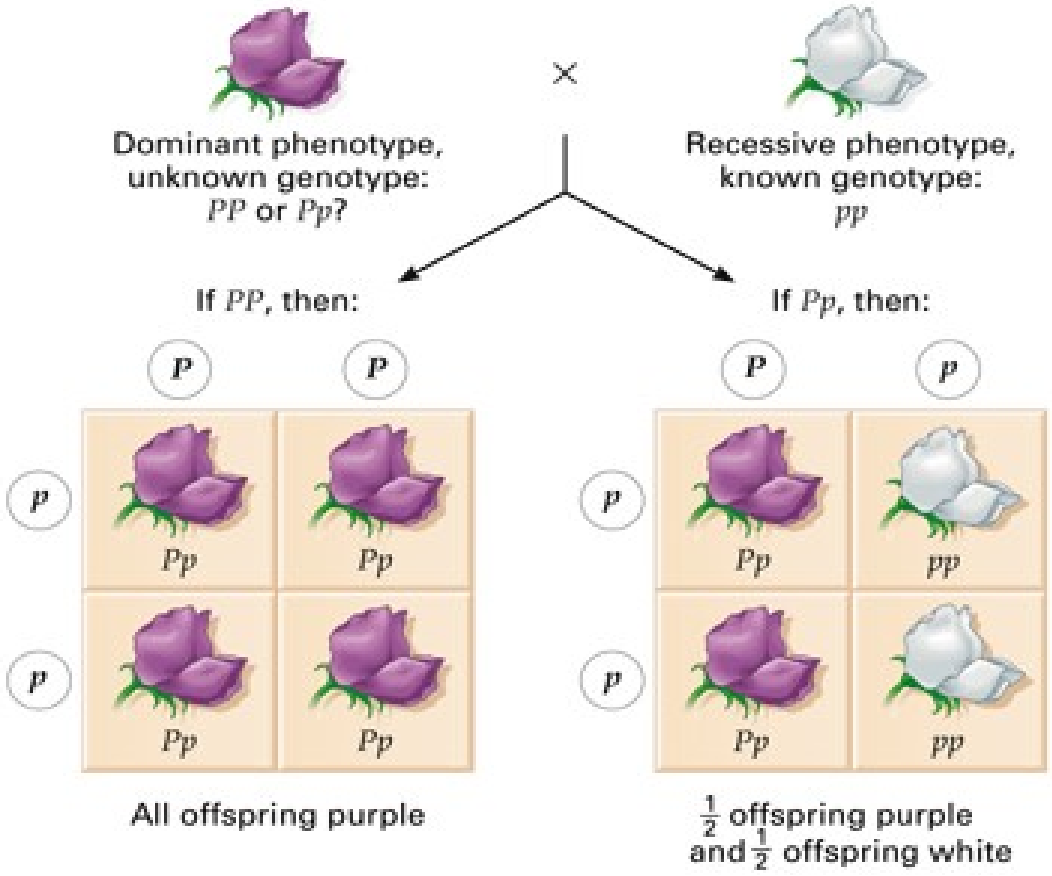
F_2 Generation

F_1 eggs



Monohybrid Cross (Test Cross)

- Analyzing the phenotypic ratios of the offspring can also help determine the genotypes of the parents.
- This is known as a **Test Cross.**



The Law of Independent Assortment

- This law states that when two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters.
- Mendel was interested in determining whether alleles at 2 different gene loci segregate dependently or independently
- Crossing two, true-breeding parents differing in two characters produces dihybrids in the F1 generation, heterozygous for both characters

Dihybrid crosses

- **Dihybrid crosses** are made when phenotypes and genotypes composed of 2 independent alleles are analyzed.
- Process is very similar to **monohybrid** crosses.
- Example:
  - 2 traits are being analyzed
  - Plant height (Tt) with tall being dominant to short,
  - Flower color (Ww) with Purple flowers being dominant to white.

Dihybrid cross example

The cross with a pure-breeding (homozygous) Tall, Purple plant with a pure-breeding Short, white plant should look like this.

	TW
tw	TtWw

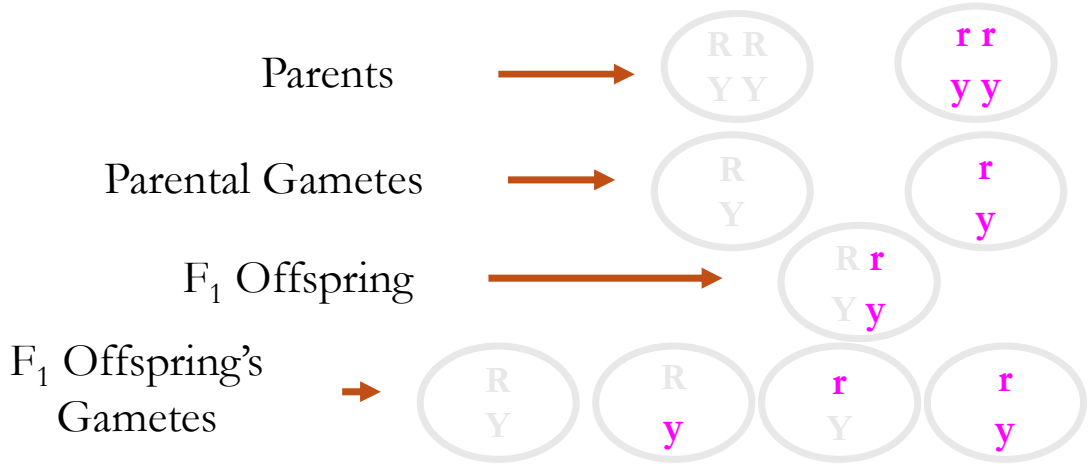
F1 generation

Dihybrid Cross

- With his monohybrid crosses, Mendel determined that the 2 alleles at a single gene locus segregate when the gametes are formed.
- With his dihybrid crosses, Mendel was interested in determining whether alleles at 2 different gene loci segregate dependently or independently.
- For example, in pea plants seed shape is controlled by one gene locus where round (R) is dominant to wrinkled (r) while seed color is controlled by a different gene locus where yellow (Y) is dominant to green (y).
- Mendel crossed 2 pure-breeding plants: one with round yellow seeds and the other with green wrinkled seeds.

Independent Segregation

- Alleles at the 2 gene loci segregate (separate) independently, and are NOT transmitted as a unit.
- Therefore, each plant would produce gametes with allele combinations that were not present in the gametes inherited from its parents:



What is the expected phenotypic ratio for the F_2?

Dihybrid cross - parental generation differs in two traits

- Example-- cross round/yellow peas with wrinkled/green ones
- Round/yellow is dominant

	RY	Ry	rY	ry
RY				
Ry				
rY				
ry				

What are the expected phenotype ratios in the F_2 generation?

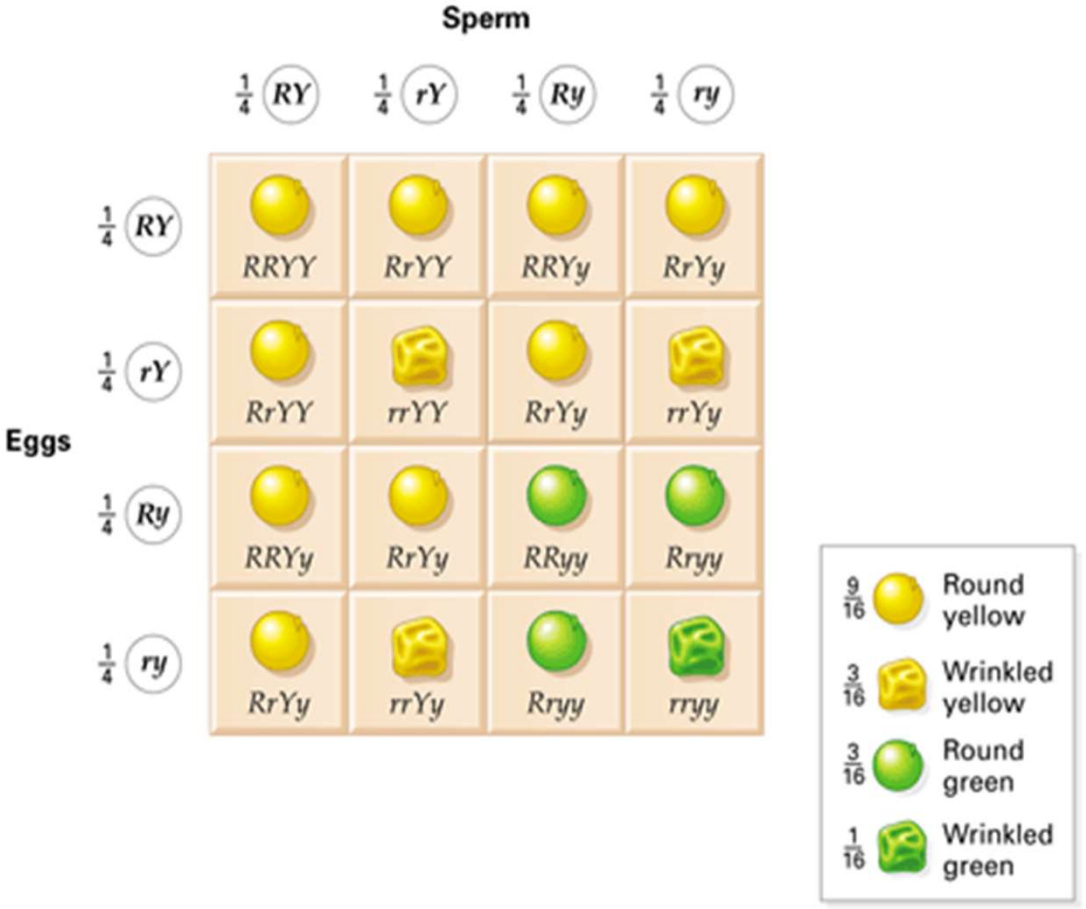
round, yellow = round, green =

wrinkled, yellow = wrinkled, green =

F_2 with Independent Assortment

	RY	Ry	rY	ry
RY	RR YY	RR Yy	Rr YY	Rr Yy
Ry	RR Yy	RR yy	Rr Yy	Rr yy
rY	Rr YY	Rr Yy	rr YY	rr Yy
ry	Rr Yy	Rr yy	rr Yy	rr yy

Phenotypic ratio is 9 : 3 : 3 : 1



Dihybrid Cross

- How are two characters transmitted from parents to offspring?
  - As a package?
  - Independently?
- A dihybrid cross
  - Illustrates the inheritance of two characters
  - Produces four phenotypes in the F2 generation

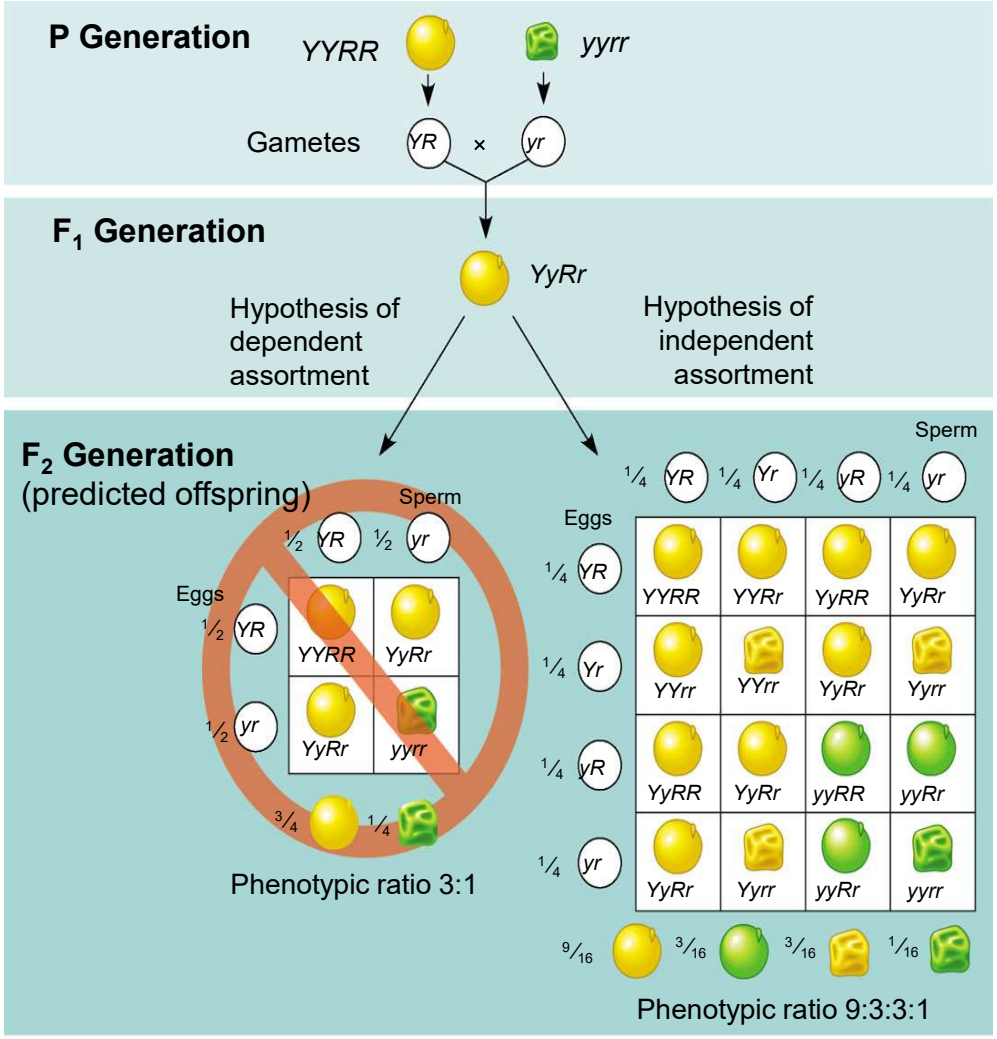
EXPERIMENT

- Two true-breeding pea plants—one with yellow-round seeds and the other with green-wrinkled seeds—were crossed, producing dihybrid F_1 plants.
- Self-pollination of the F_1 dihybrids, which are heterozygous for both characters, produced the F_2 generation.
- The two hypotheses predict different phenotypic ratios. Note that yellow color (*Y*) and round shape (*R*) are dominant.

CONCLUSION

The results support the hypothesis of independent assortment.

The alleles for seed color and seed shape sort into gametes independently of each other.



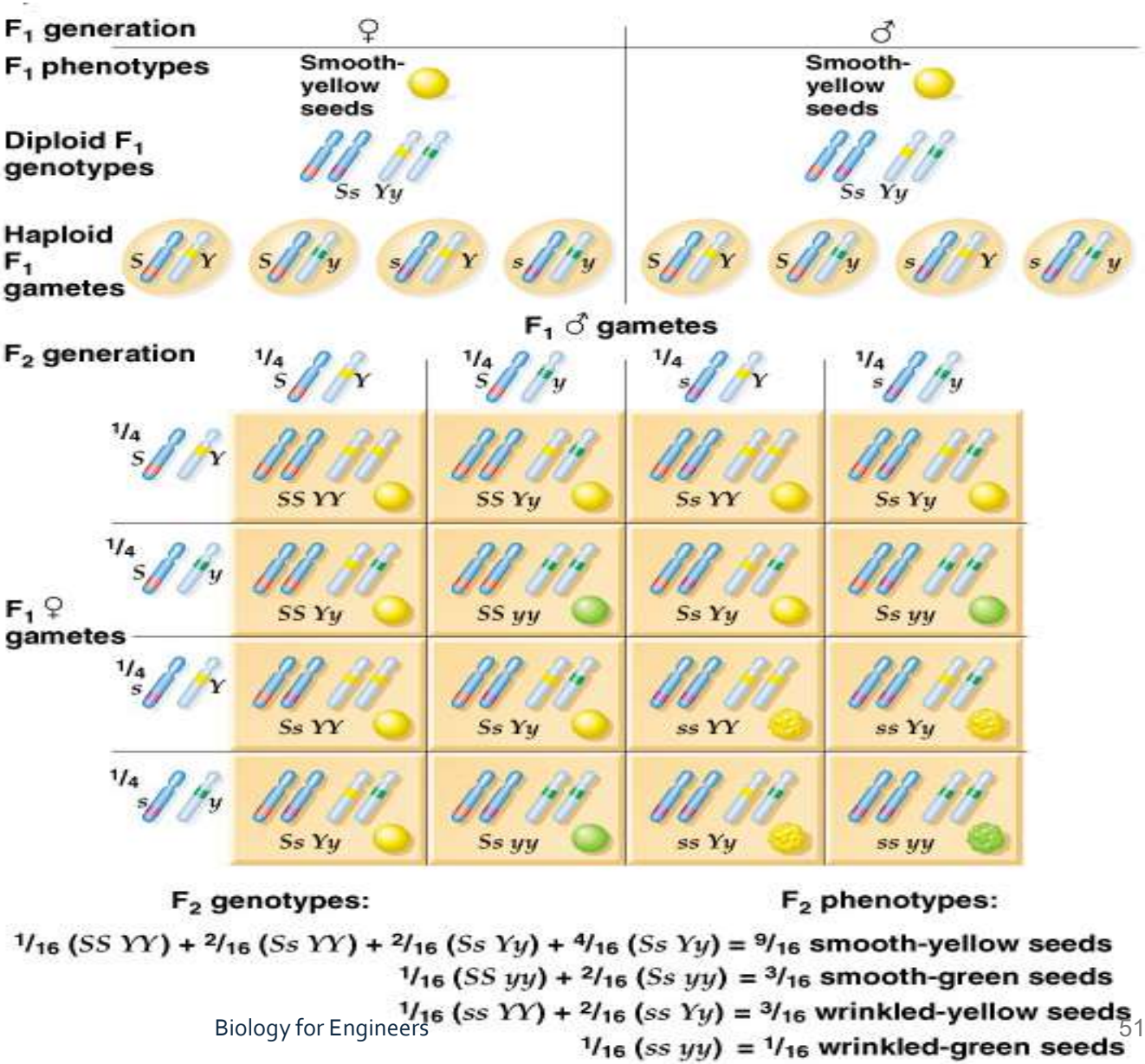
315 108 101 32

Phenotypic ratio approximately 9:3:3:1

Dihybrid cross

- **F_2 generation ratio:**

  9:3:3:1



F_2 genotypes: **F_2 phenotypes:**

$^1/_{16}$ (*SS YY*) + $^2/_{16}$ (*Ss YY*) + $^2/_{16}$ (*Ss Yy*) + $^4/_{16}$ (*Ss Yy*) = $^9/_{16}$ **smooth-yellow seeds**

$^1/_{16}$ (*SS yy*) + $^2/_{16}$ (*Ss yy*) = $^3/_{16}$ **smooth-green seeds**

$^1/_{16}$ (*ss YY*) + $^2/_{16}$ (*ss Yy*) = $^3/_{16}$ **wrinkled-yellow seeds**

$^1/_{16}$ (*ss yy*) = $^1/_{16}$ **wrinkled-green seeds**

homework

T*t* P*p* × T*t* P*p*

(tall, purple) (tall, purple)

Mendel's Conclusions

- Genes are distinct entities that remain unchanged during crosses
- Each plant has two alleles of a gene
- Alleles segregated into gametes in equal proportions, each gamete got only one allele
- During gamete fusion, the number of alleles was restored to two

Summary of Mendel's Principles

- **Mendel's Principle of Uniformity in F1**:
  - F1 offspring of a monohybrid cross of true-breeding strains resemble only one of the parents.
  - Why? Smooth seeds (allele S) are completely dominant to wrinkled seeds (alleles).
- **Mendel's Law of Segregation**:
  - Recessive characters masked in the F1 progeny of two true-breeding strains, reappear in a specific proportion of the F2 progeny.
  - Two members of a gene pair segregate (separate) from each other during the formation of gametes.
- **Mendel's Law of Independent Assortment**:
  - Alleles for different traits assort independently of one another.
  - Genes on different chromosomes behave independently in gamete production.

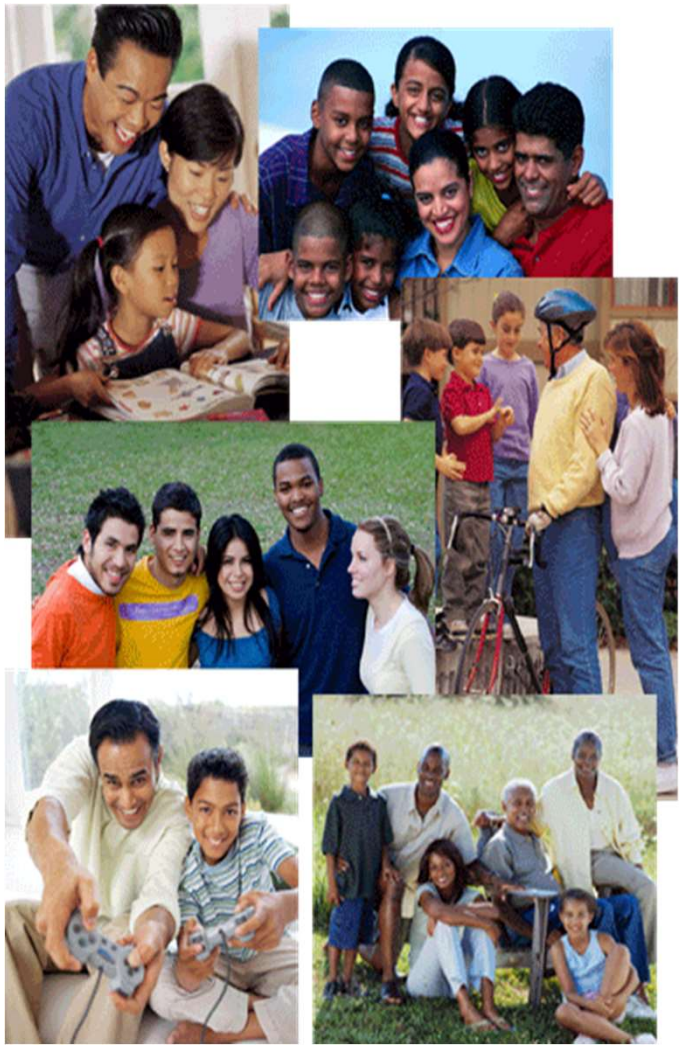
You don’t look like…..

Have you ever been told that you resemble one parent more than the other?

The reason for this may be due to having received more dominate genes from the parent you resemble.

However, you receive half of all your chromosomes and genes from each parent.

Each parent passes to you 23 chromosomes for a total of 46 chromosomes.



“Oh’ Boy A Take Home Lab!”

STRATEGY:

- You will examine ten of your genetic traits.
- You will examine your parents for these same traits.
- You can then compare how similar or how different you are to each parent.

PROCEDURE:

Complete the column marked YOU for the genetic traits to be examined.

Ask your classmates to assist you in describing certain traits that you may not be able to see, such as ear lobe shape or hair whorl.

TRAIT	DESCRIPTION	YOU	FATHER	MOTHER
Handedness	Left or right			

TRAIT	DESCRIPTION	YOU	FATHER	MOTHER
Sight	Nearsighted or Normal			

TRAIT	DESCRIPTION	YOU	FATHER	MOTHER
Eye color	Blue/Black/Brown /Green			

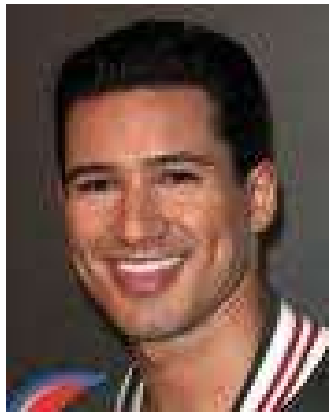
Brown eyes

Blue eyes

Green eyes

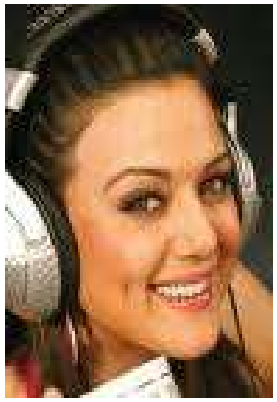
Hazel eyes

TRAIT	DESCRIPTION	YOU	FATHER	MOTHER
Dimples	Yes or No			



Mario Lopez

Deepika Padukone



Zinta

SRK

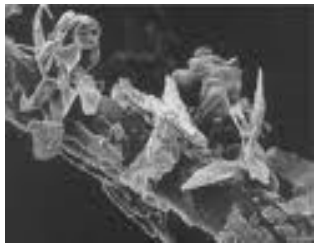
TRAIT	DESCRIPTION	YOU	FATHER	MOTHER
Allergies	Yes or No			

Pollen

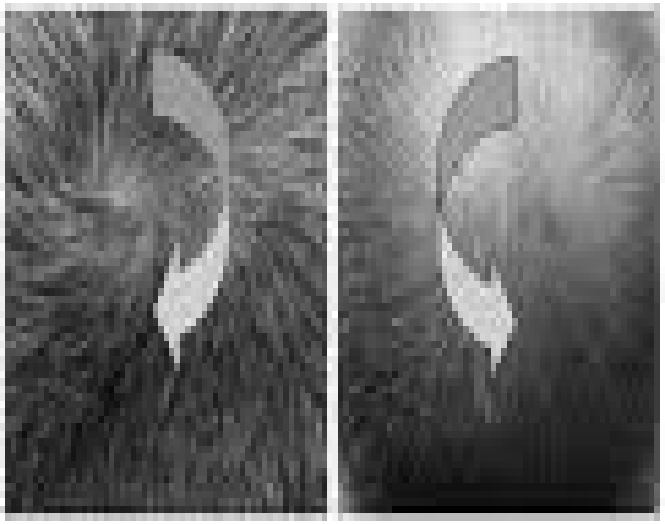
Food

Medication

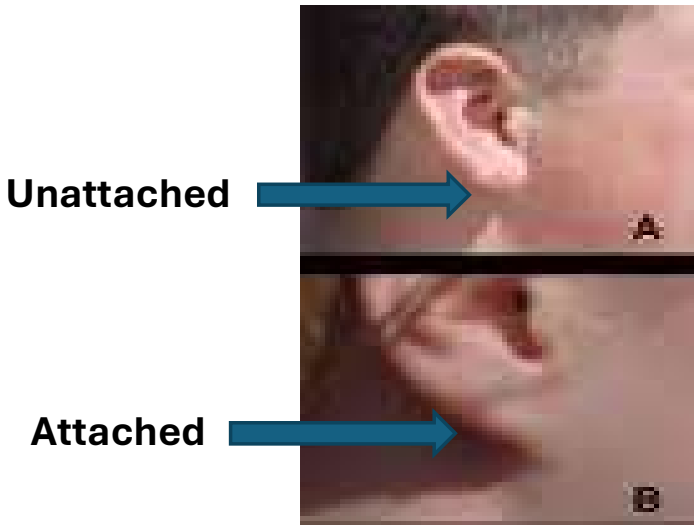
Animal hair dander

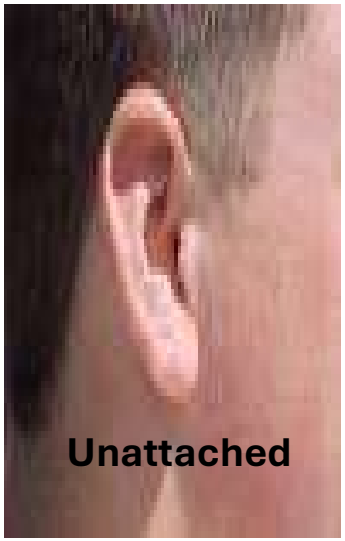


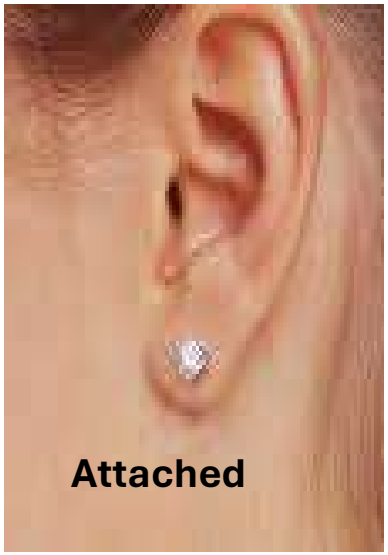
TRAIT	DESCRIPTION	YOU	FATHER	MOTHER
Hair Whorl	Clockwise or Counter-clockwise			



TRAIT	DESCRIPTION	YOU	FATHER	MOTHER
Ear lobe	Free or Attached			







TRAIT	DESCRIPTION	YOU	FATHER	MOTHER
Eye shape	Close set, Deep set, Hooded, Almond, Down turned,			

Close Set Eyes

Eyes narrower than one eye width are regarded as close set. Use light colours on the inner corners, and extend the outer corners using dark colours. Line outer corners, use mascara on outer corners.

Deep Set Eyes

The eye is deep into the socket, with a small mobile lid. Apply light colours on the mobile lid, with a deeper colour on and just above the socket line, blending up and out.

Hooded Eyes

A fold of skin hangs over the socket line. This happens with age. Use matte colours in medium to dark and keep eye make up simple.

Almond Eyes

Considered to have "perfect" proportions, any eye technique will work.

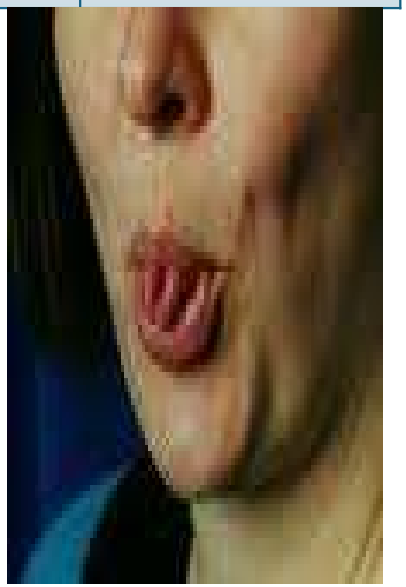
Down Turned Eyes

The focus for this eye shape, is to shade "up and out". Apply liner close to the upper lash line and blend shadow along the socket line in the outer 2/3 of the eyes. Curling lashes and applying mascara can also help to "lift" the eyes.

Protruding Eyes

This eye shade has a bulge from the sock to the lash and can be difficult to work with. The best way to shade this eye is use medium to dark matte colours as illustrated below.

TRAIT	DESCRIPTION	YOU	FATHER	MOTHER
Tongue	Roller or Non-roller			



Rollers

REFERENCES

- Gupta, P.K.. Cytology, Genetics and Molecular Biology, Rastogi Publishers, Meerut, 1993.
- Roit I.M., Brostoff J. and Male D. Mosby .Immunology (6 th Edition) by, An imprint of Elsevier Sci Ltd., 2002.
- https://www.youtube.com/watch?v=wv1TQXBQ6wQ
- https://www.youtube.com/watch?v=zNEtVaNQ0s8
- (http://www.nlm.nih.gov/medlineplus/ency/article/002048.htm)
- https://nptel.ac.in/courses/121/106/121106008/
- https://www.utoledo.edu/engineering/bioengineering/undergrad/prospective/whatisbioe.html#:~:text=Bioengineering%20is%20the%20application%20of,health%20care%20and%20other%20fields.
- https://i.pinimg.com/originals/68/c9/30/68c930e95113ceb2e3dfc9de2f164680.png
- https://youtu.be/FBUpnG1G4yQ

THANK YOU

For queries
Email: devinder.e11172@cumail.in