MENDELISM
(Mendelian Genetics)

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Vocabulary

Locus

Allele

Genotype

Phenotype

Heterozygous

Homozygous

Dominant

Recessive

Law of segregation

P

F1

F2

Monohybrid

Dihybrid

Gregor Mendel

- Mendel was an Austrian monk at the St Thomas monastry in Brünn (Brno, Czech Republic).
- Studied Botany and Mathematics.
- Carried out ground breaking studies on inheritance

https://www.youtube.com/watch?v=Mehz7tCxjSE

- Discovered the basic principles of heredity.
- Worked with the common garden pea plant, *Pisum sativum.*
- *Why do you think he choose pea plants?*

Reasons for choosing the pea plant

- The pea plant was easy to cultivate with relatively short life cycle (annual plant).
- Has discontinuous characteristics such as flower color and pea texture.
- Perfect flowers (i.e., both female and male parts are present on one plant) and can be self-fertilized (i.e. the ovule is fertilized by pollen from the same flower.

Features of Mendel's Experiment

- Paid attention to a single character at a time. e.g., the shape of the seeds rather the whole plant.

- ***Characters*** are noticeable features that vary among individuals. Each variant of a character is a ***trait.***

Traits	Shape of Seeds	Color of Seeds	Color of Pods	Shape of Pods	Plant Height	Position of Flowers	Flower Color
Dominant trait	Round 	Yellow	Green 	Full 	Tall 	At leaf junctions 	Purple 
Recessive trait	Wrinkled 	Green 	Yellow 	Flat, constricted 	short 	At tips of branches 	White 

Features of Mendel's Experiment

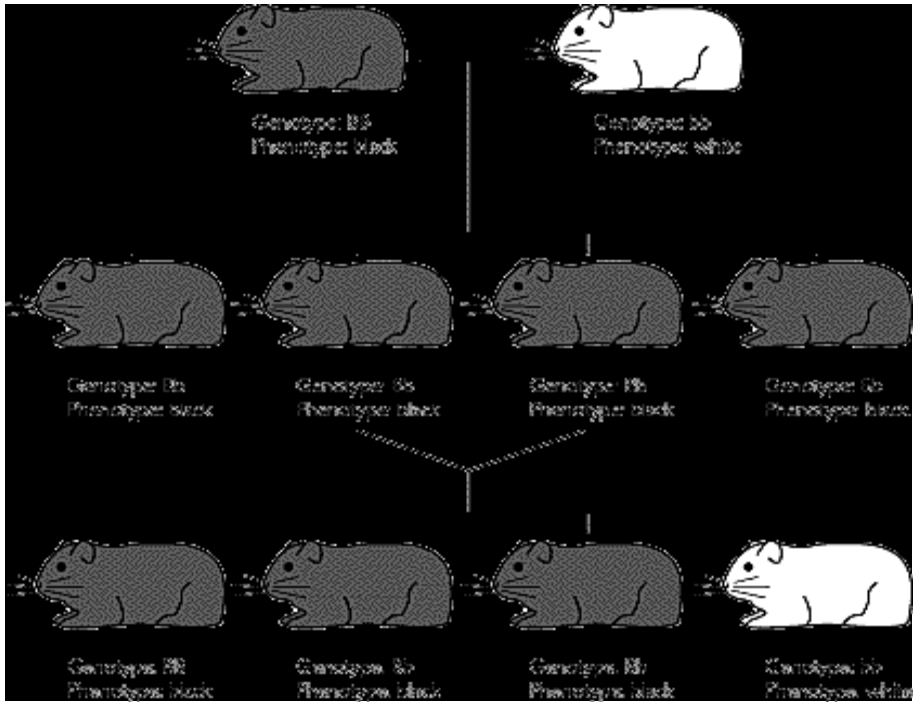
- Mendel chose to examine only traits that were simple: on or off

✓ We now know these are <u>single</u> gene traits.

✓ Traits such as yield, and seed weight are multiple gene traits known as ***quantitative*** traits.

Multiple gene versus single gene

Trait controlled by single genes -on-or-off



Trait controlled by multiple genes

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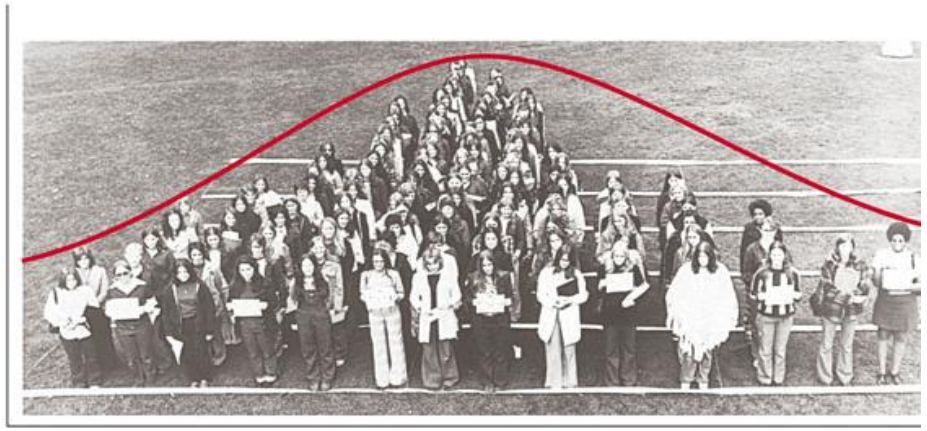


Height in inches

Gene

- Gene = A length of DNA that codes for a particular protein.
- Proteins determine an inherited trait.
- Genes reside on chromosomes. Location of that gene on a chromosome is known as its ***locus.***

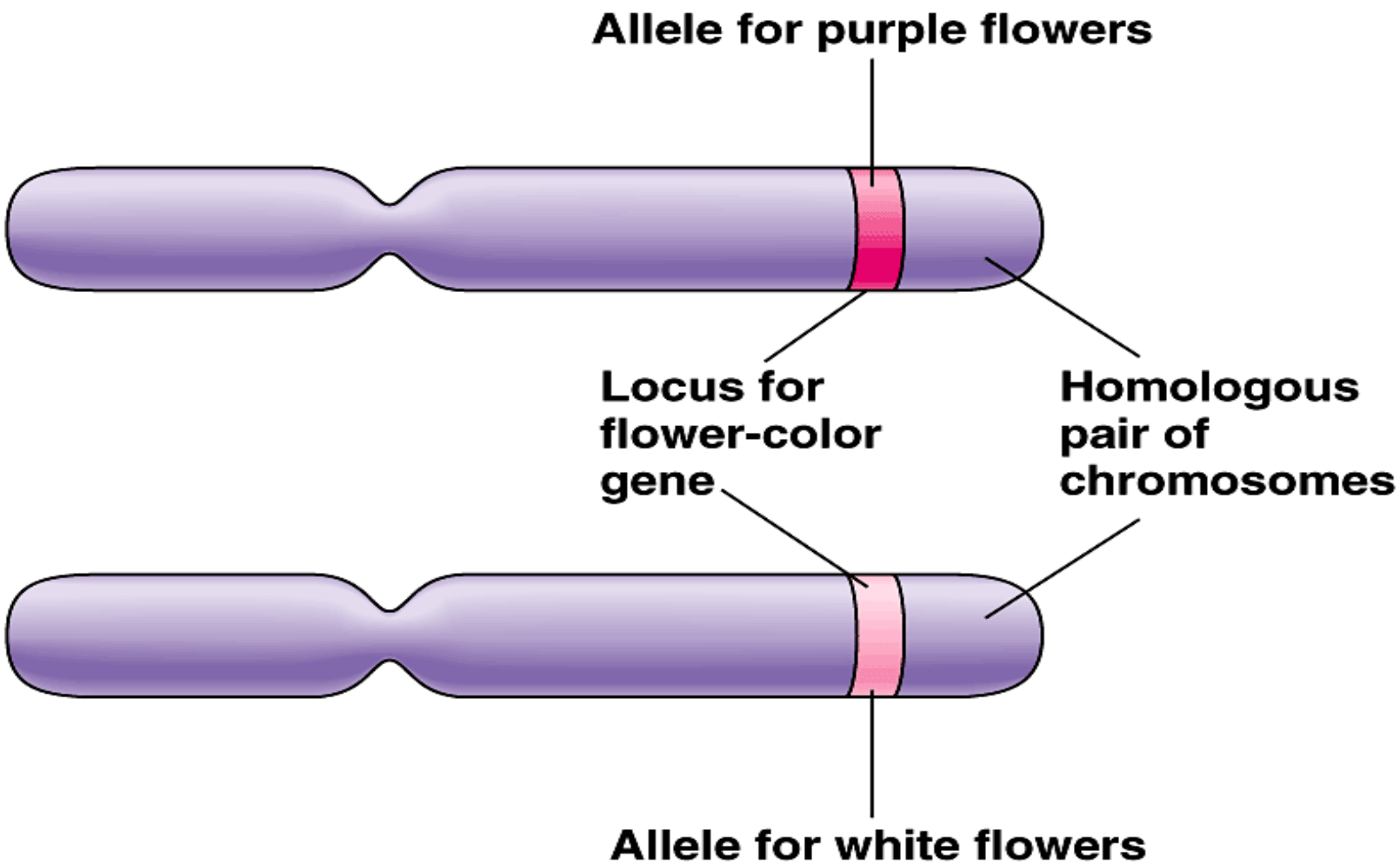
Allele

- **Allele** is a variation of a gene; the different forms of a gene that determine alternative traits.

  – Each homologous chromosome has one allele

  – Every different version is an allele of that gene

Example of Allele



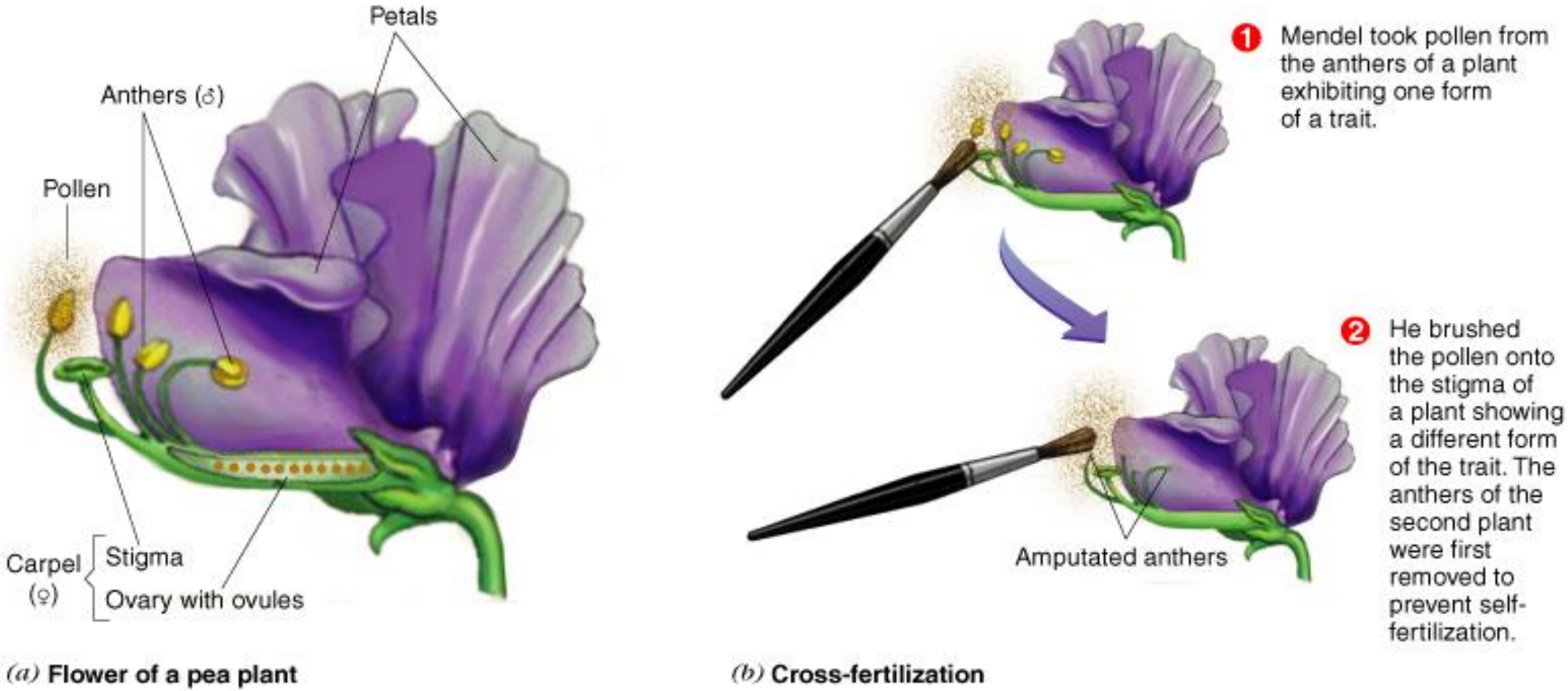
- Another important feature of Mendel's work was his ***quantitative approach.***

- He counted the number of progenies of each kind to ascertain whether carriers of alternate traits always appeared in the same proportions.

Mendel's Experiment

- Prevented self-fertilization by removing anthers from "test" flowers.
- He studied traits that show alternative forms. E.g., tall vs. dwarf.
- In the parental, or P_1 generation, tall plants were pollinated by dwarf plants and vice versa.

(a) Flower of a pea plant, cut to show male and female flower parts. (b) Using artificial cross-fertilization, Mendel controlled mating between plants.



Mendel's Experiment

- Offspring of the cross of P_1 individuals are referred to as the first ***filial generation,*** or ***F_1.*** The F_1 are also referred to as ***Hybrids.***

- When tall hybrid plants (1064) were self-fertilized and the F_2 classified, some were tall (787) and some dwarf (277)

- A nearly perfect 3:1 ratio (2.84:1).

Other terminologies

- A ***hybrid*** is the offspring resulting from combining the qualities of two organisms of different breeds, varieties, species or genera through sexual reproduction.

- ***Monohybrid*** refer to a hybrid that is heterozygous with respect to a specified gene e.g., the offspring of tall and dwarf peas.

- They are hybrid for *only* one characteristic e.g., height.

- Since all the F_1 offspring were tall, they (tall) were referred to as the ***Dominant*** trait.

- The alternative trait (i.e., dwarfness) is called ***recessive.***

- Dominance applies to the appearance of a trait in the ***heterozygous*** condition.

- Zygotes of individual organisms carrying two units of one allele (DD or dd) are ***homozygous*** and those with two different alleles (Dd) are ***heterozygous.***

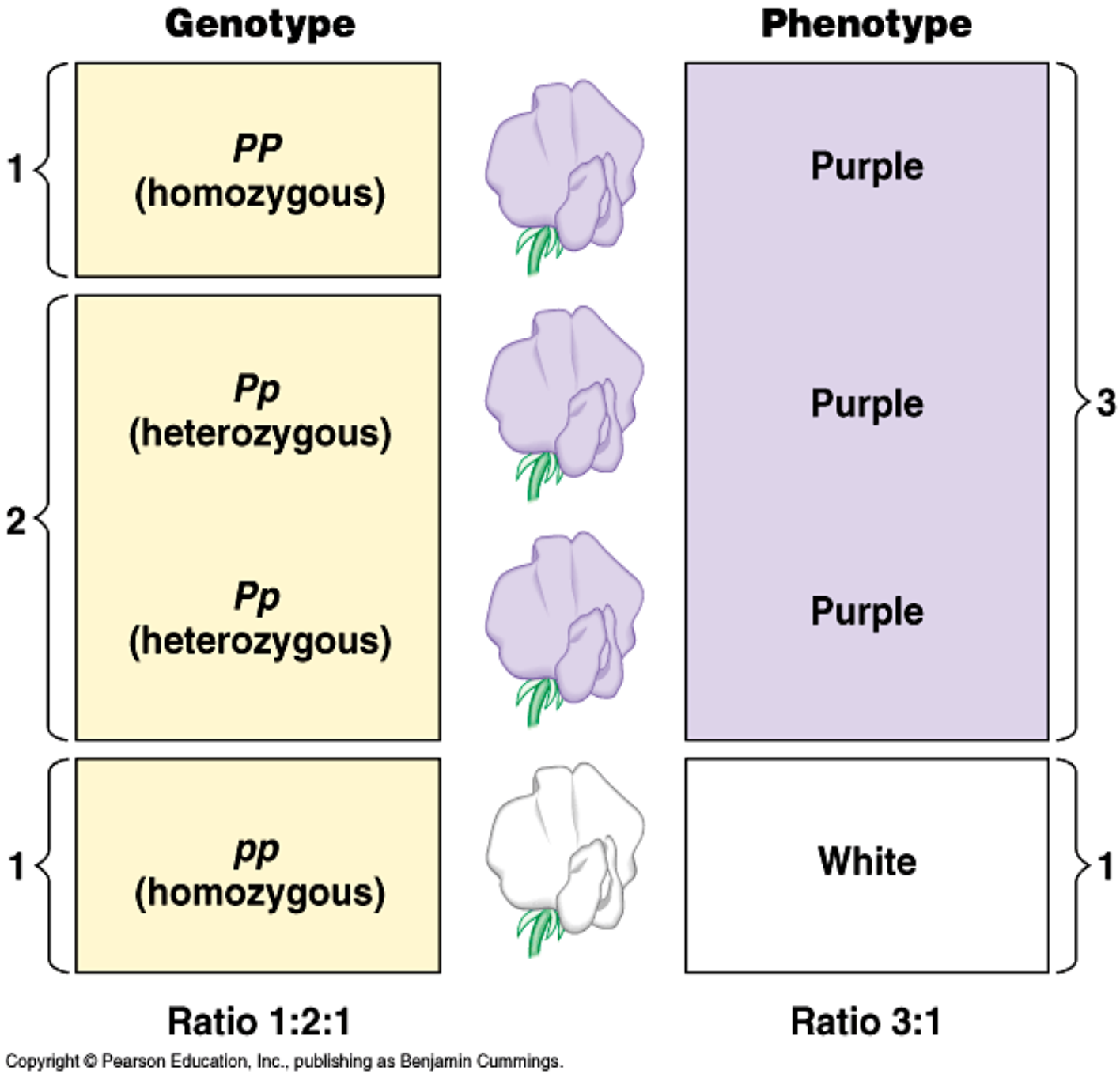
- ***Phenotype*** refers to the visible expression of a trait or it is any measurable characteristic or distinctive trait possessed by an organism.

- The trait may be visible to the eye, such as color of a flower or the texture of hair.

- The phenotype is the result of gene products brought to expression in a given environment.

- ***Genotype*** refers to the type of genes an organism possesses. Or it is all the alleles possessed by an individual. Example; TT, Tt and tt.

Genotype vs. Phenotype



Principles of Segregation

- During sexual reproduction, the members of each of alleles (e.g TT, Tt or tt) separate into different reproductive cells or gametes of the male and female parents.

- The gametes then fuse and give rise to the progeny.

Principles of Segregation

- Fertilization gives each new individual two factors for each trait.

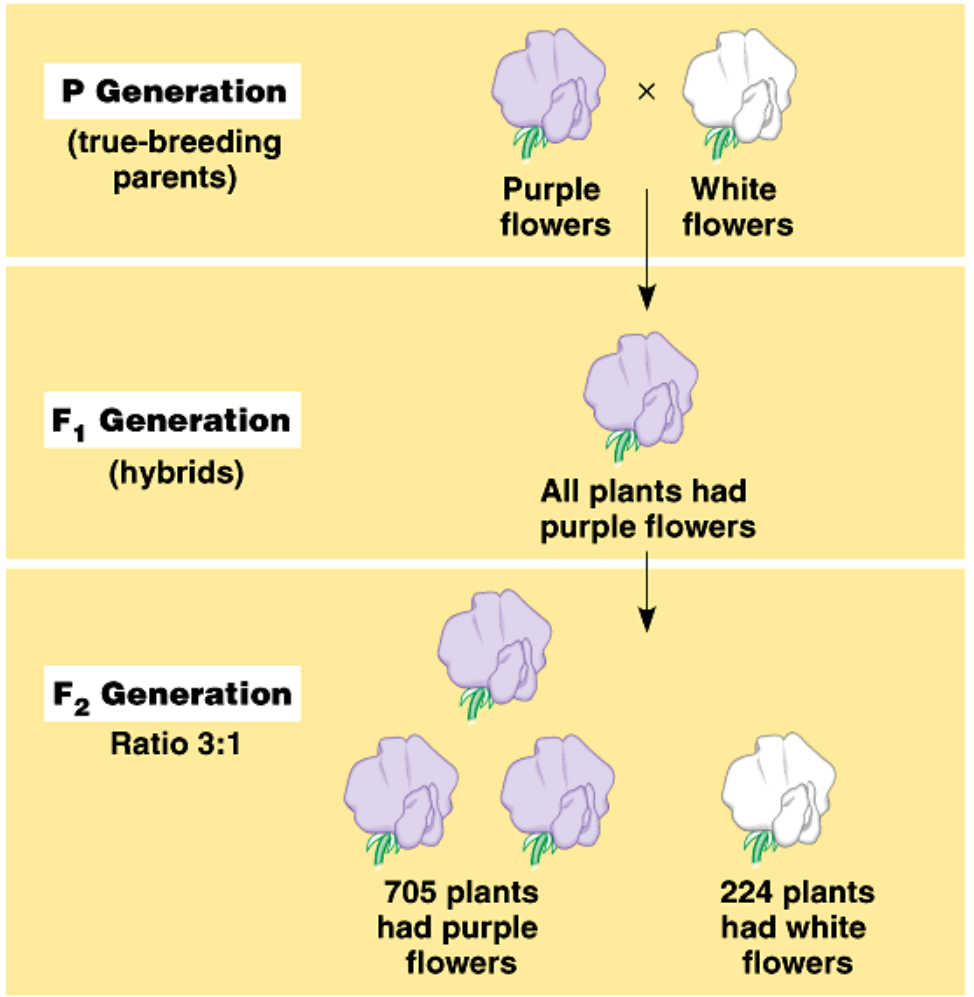
- Mendel called this, the principle or rule of segregation

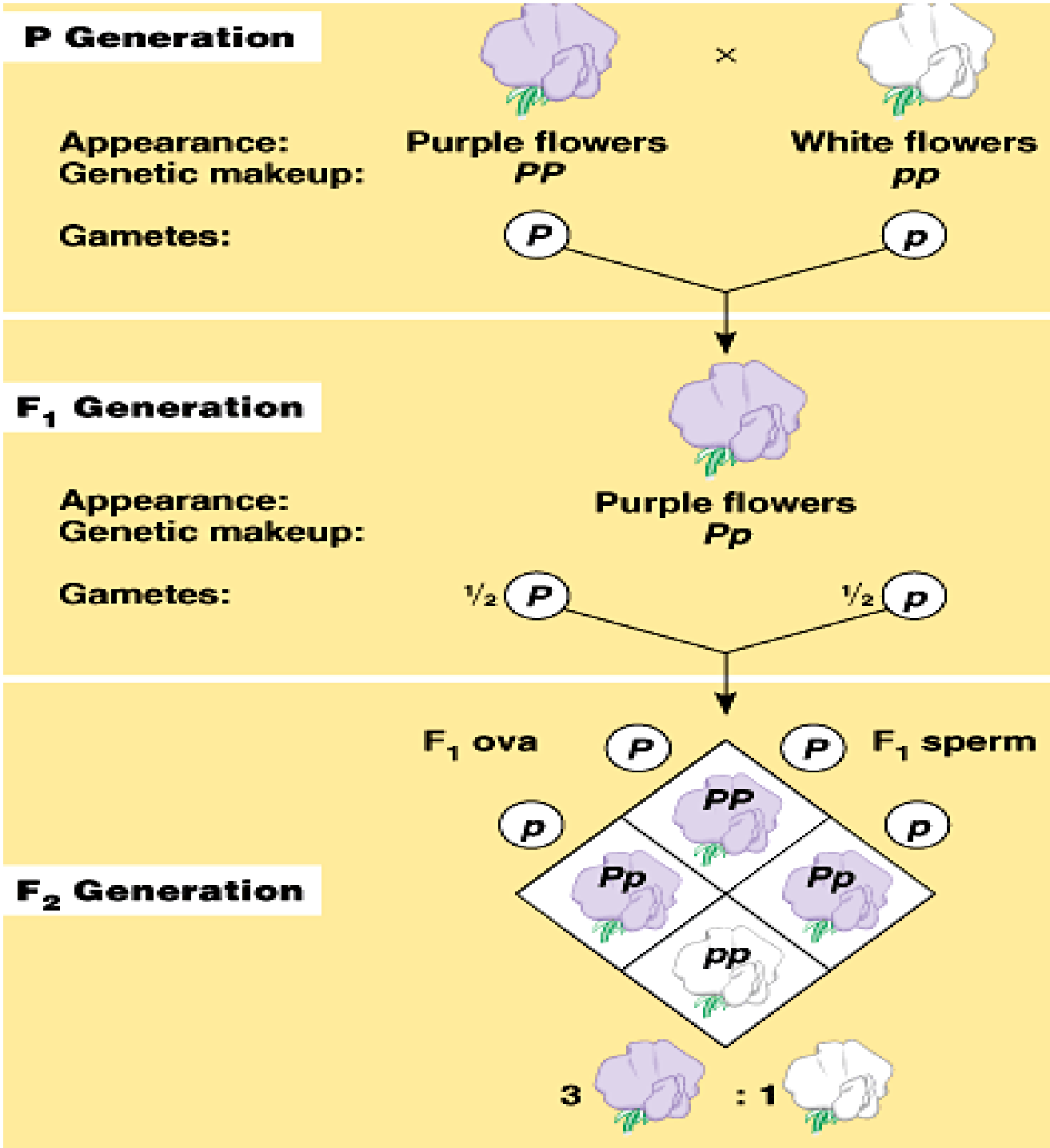
- The significant inference from his results was that the separation or segregation of pairs of determiners resulted in “purity of gametes”.

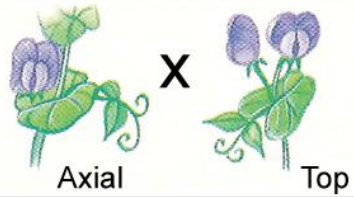
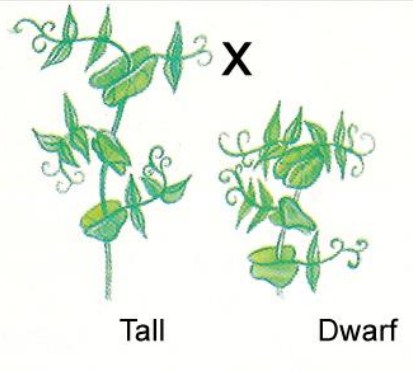
- The concept of segregation can be phrased as the ***separation of paired genes (allelic pairs) from one another and their distribution to different sex cells***

Mendel tracked characters for numerous generations

- **P** = parental
- $\mathbf{F_1}$ = first filial (son) generation
- $\mathbf{F_2}$ = Second filial generation
- Mendel noticed a pattern of inheritance




P Generation
Appearance:
Genetic makeup:
Purple flowers
PP
×
White flowers
pp
Gametes:
P
p
F1 Generation
Appearance:
Genetic makeup:
Purple flowers
Pp
Gametes:
½ P
½ p
F2 Generation
F1 ova
P
P
F1 sperm
p
p
PP
Pp
Pp
pp
3
: 1

Trait	Dominant vs. recessive	F_2 generations Dominant form	Recessive form	Ratio
Flower color	 Purple X White	705	224	3.15:1
Seed color	 Yellow X Green	6022	2001	3.01:1
Seed shape	 Round X Wrinkled	5474	1850	2.96:1
Pod color	 Green X Yellow	428	152	2.82:1
Pod shape	 Round X Constricted	882	299	2.95:1
Flower position	 Axial X Top	651	207	3.14:1
Plant height	 Tall X Dwarf	787	277	2.84:1

P generation Tall x dwarf

TT tt

Meiosis ↓ ↓

Gametes (T) (t)

F_1 generation Tt Tall (hybrid)

Tt x Tt (inbred)

Meiosis ↓ ↓

Gametes (T) (t) (T) (t)

♀ / ♂	**T**	**t**
T	TT (tall)	Tt (dwarf)
t	Tt (tall)	tt (dwarf)

F_2 generation

Gametes

Phenotypic ratio = 3 : 1

Genotypic ratio = 1 : 2 : 1

Testing the Principle

- It must be noted that, the separation of the alleles could be detected only in the heterozygous parent (Dd) that produced two different kinds of gametes: (D) and (d)

- The dwarf (dd) could produce only one kind of gamete (d)

Testing the Principle

- When the F_1 (Dd) were crossed back to the dwarf (dd) variety, half the progeny was tall, and half were dwarf.

- This demonstrates more conclusively the principle.

Recessiveness

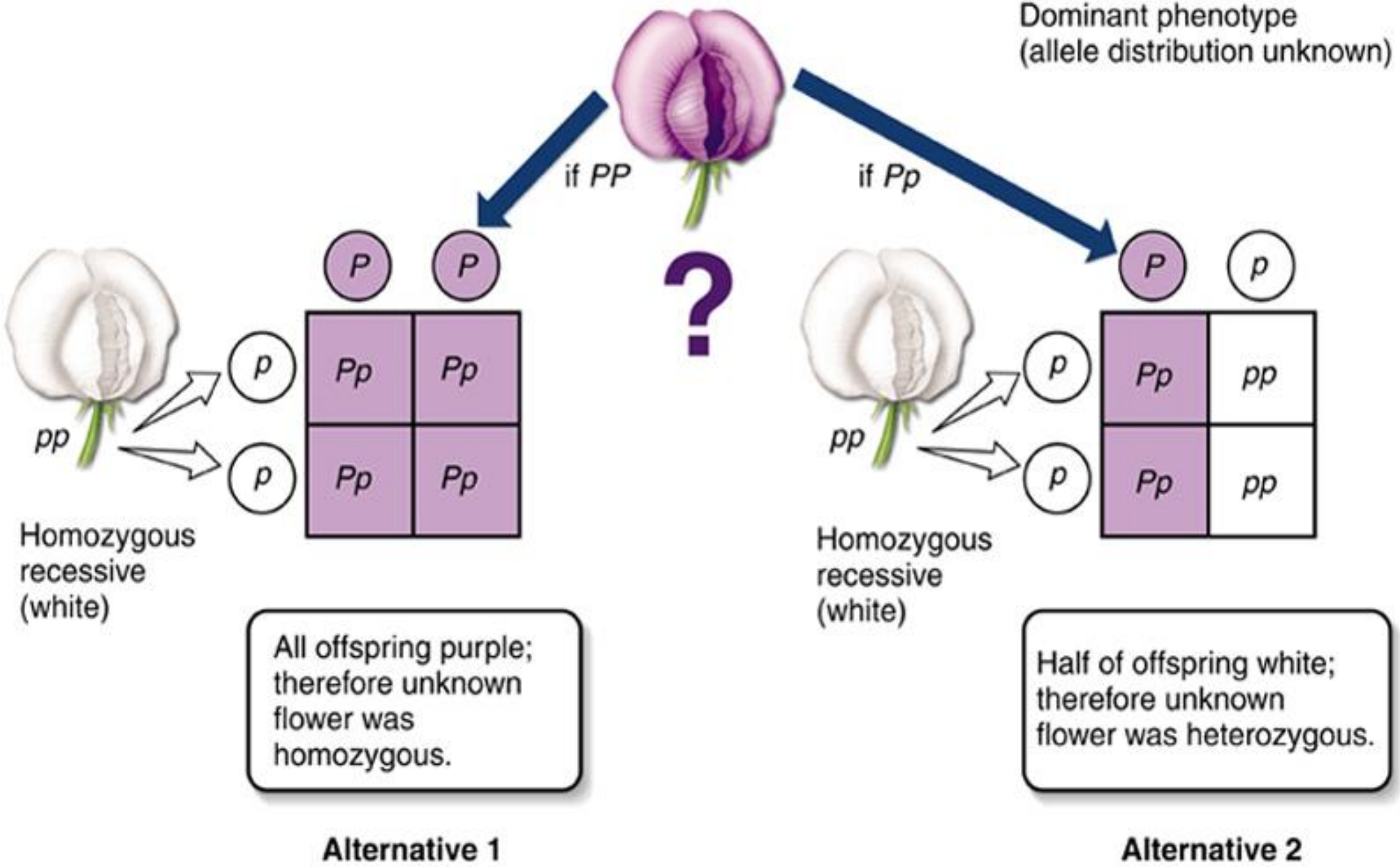
- Recessive alleles are expressed only in homozygous (dd) individuals.
- Carriers (Dd) are not detectable phenotypically.
- Recessive alleles can be identified experimentally by crossing potential carriers to homozygous recessive individuals.

- Such a cross of an organism with an unknown genotype to a known homozygous recessive organism is called a **testcross.**

- Testcrosses are very useful in genetics in determining the genotypes of individual organisms.

Backcross

- In backcross, the F_1 (progeny) is mated or crossed back to one of their parents or with an individual that has a parental genotype.



- The difference between the two crosses is that;

- *In the testcross, a recessive homozygote is always used as one of the testcross parents; this is not necessarily true in a backcross*