Mendelian inheritance

Mendelian concept of inheritance

- Gregor Mendel (1822-1884), conducted hybridisation experiments on garden peas for seven years (1856-1863) and proposed the laws of inheritance in living organisms.
- It has been credited as one of the great experimental advances in biology (Fisher, 1965).
- His success was “introduction of the concept of a *genetic model*”.
- genetic models were very simple forms for dichotomous traits that lead to deterministic outcomes.
- Genetic models underlie most analyses used in statistical genetics.
- Known as Father of Genetics

- Genetics deals with the inheritance, as well as the variation of characters from parents to offspring.
- Inheritance is the process by which characters are passed on from parent to progeny; it is the basis of heredity.

- Mendel was: a gardener; studied philosophy and physics at University of Olomouc, Czech republic ; studied natural history and agriculture; substitute high school teacher; failed to get a certificate for teacher; again worked as physics teacher ; Finally he was taken the superior priest of the monastery.

- In 1900 Three botanist Hugo De Vries of Holland, Tshermark in Austria and Correns in Germany working independently had common conclusions
- Mendel investigated characters in the garden pea plant that were manifested as two opposing traits, e.g., tall or dwarf plants, yellow or green seeds.

Mendel’s work can be divided into the following steps:

(A) Preparation for experiments

(B) Choice of experimental material

(C) Planning and execution of experiment

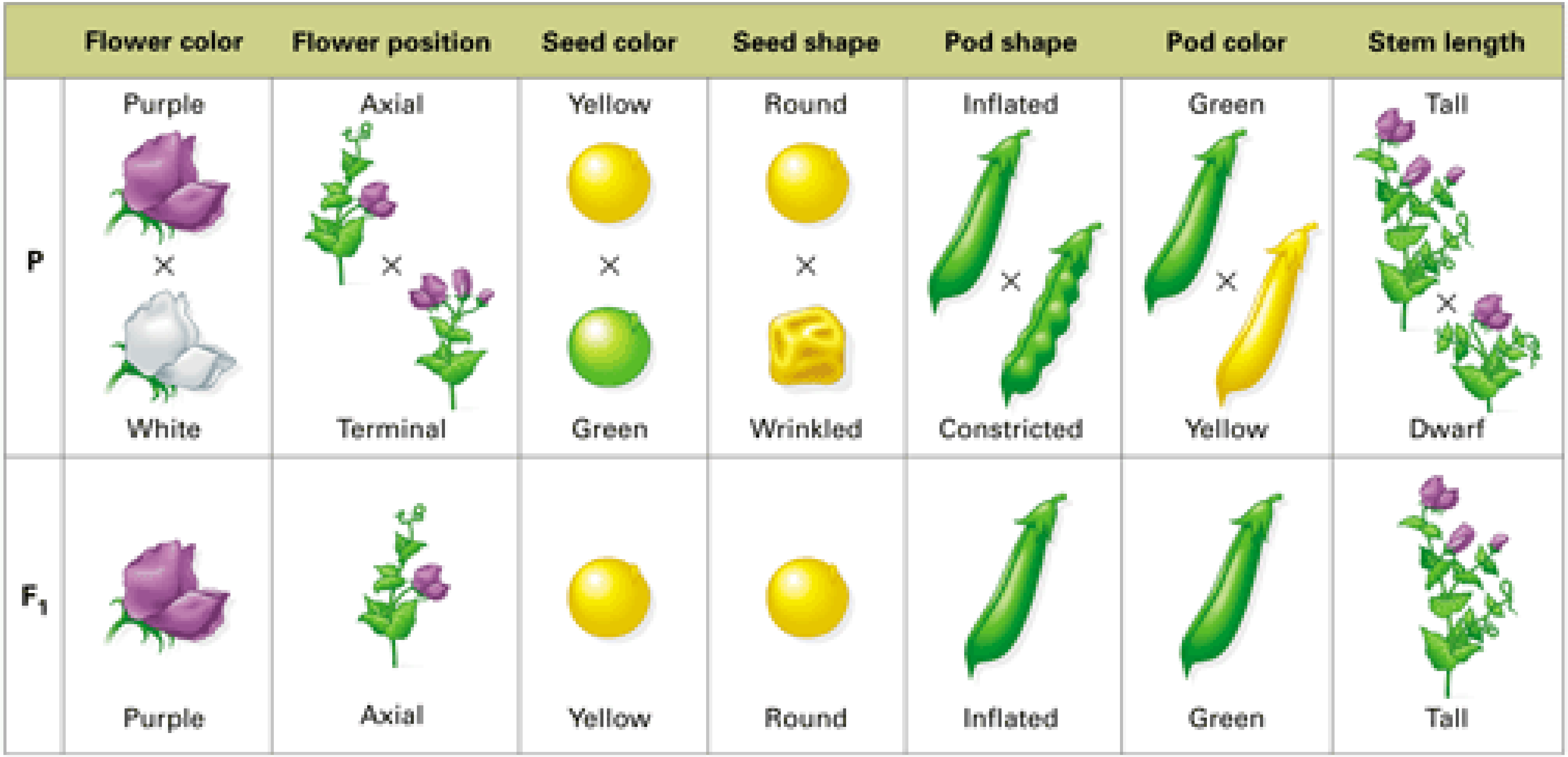
(D) Interpretation of experimental results and

(E) Further testing of his observations.

- Mendel conducted artificial pollination (fertilization) /cross pollination (fertilization) experiments using several true-breeding pea lines.

Pisum Sativum (Been plant)

Mendel’s experiments



Logic behind Mendel's Experiment

The first logic of Mendel:

Easy recognizable separate characters for observation -that had well-defined, contrasting alternative traits

The second logic:

He conducted multiple experiments for different characters

The third logic:

Did Mendel randomly selected seeds? We should know which characters seeds are inherited? (Mendel used well defined seeds as the starting material (1000 nos))

The fourth logic:

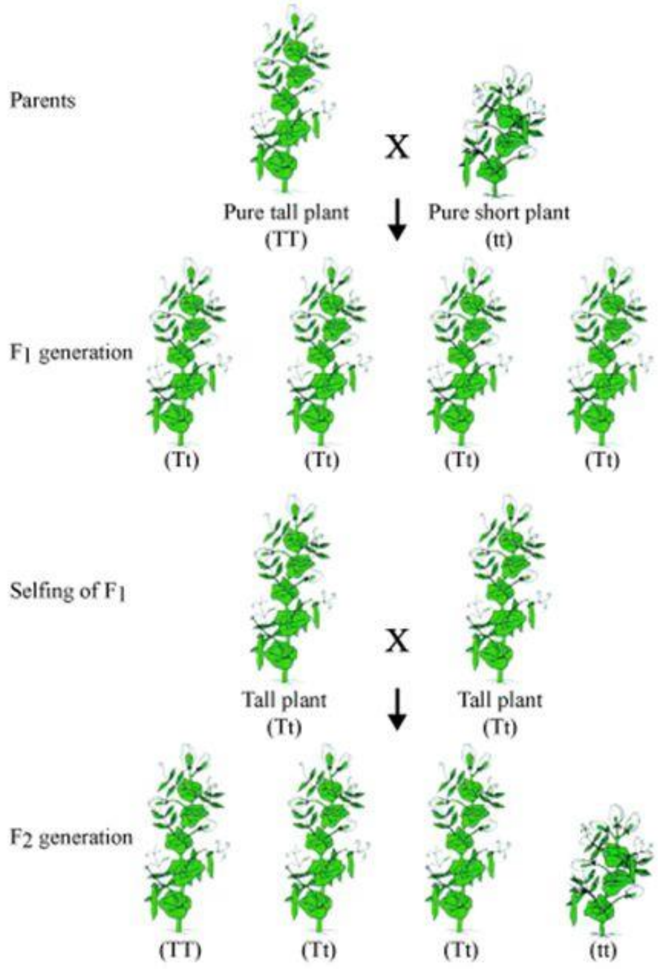
How to do experimental controlled breeding? (Bagging)

The fifth logic:

He just crossed only once i.e. he allowed mixing of two different characters only once

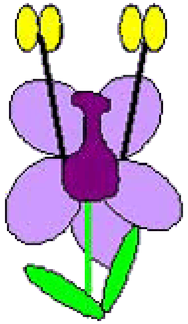
The sixth and final logic:

Looking behind a character how many generations we should follow after crossing? Just followed the first generation after crossing.

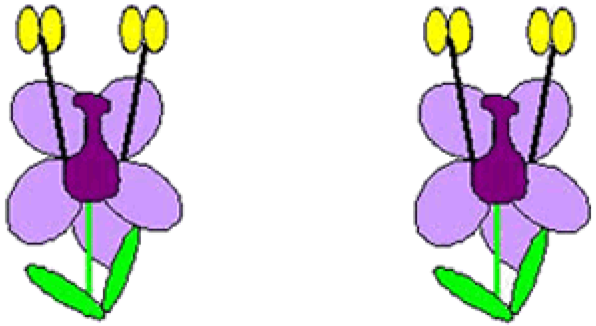


Crossing a true-breeding regular pea plant with a true-breeding dwarf pea plant produces all regular pea plants in the first generation.

Allowing the first generation pea plants to self-pollinate resulted in about three-fourths regular pea plants and one-fourth dwarf pea plants.



(self fertilization)



(cross fertilization)

Research method of Mendel

- Mendel crossed pea plants that differed in certain characteristics and traced the traits from generation to generation
- This illustration shows his technique for cross-fertilization

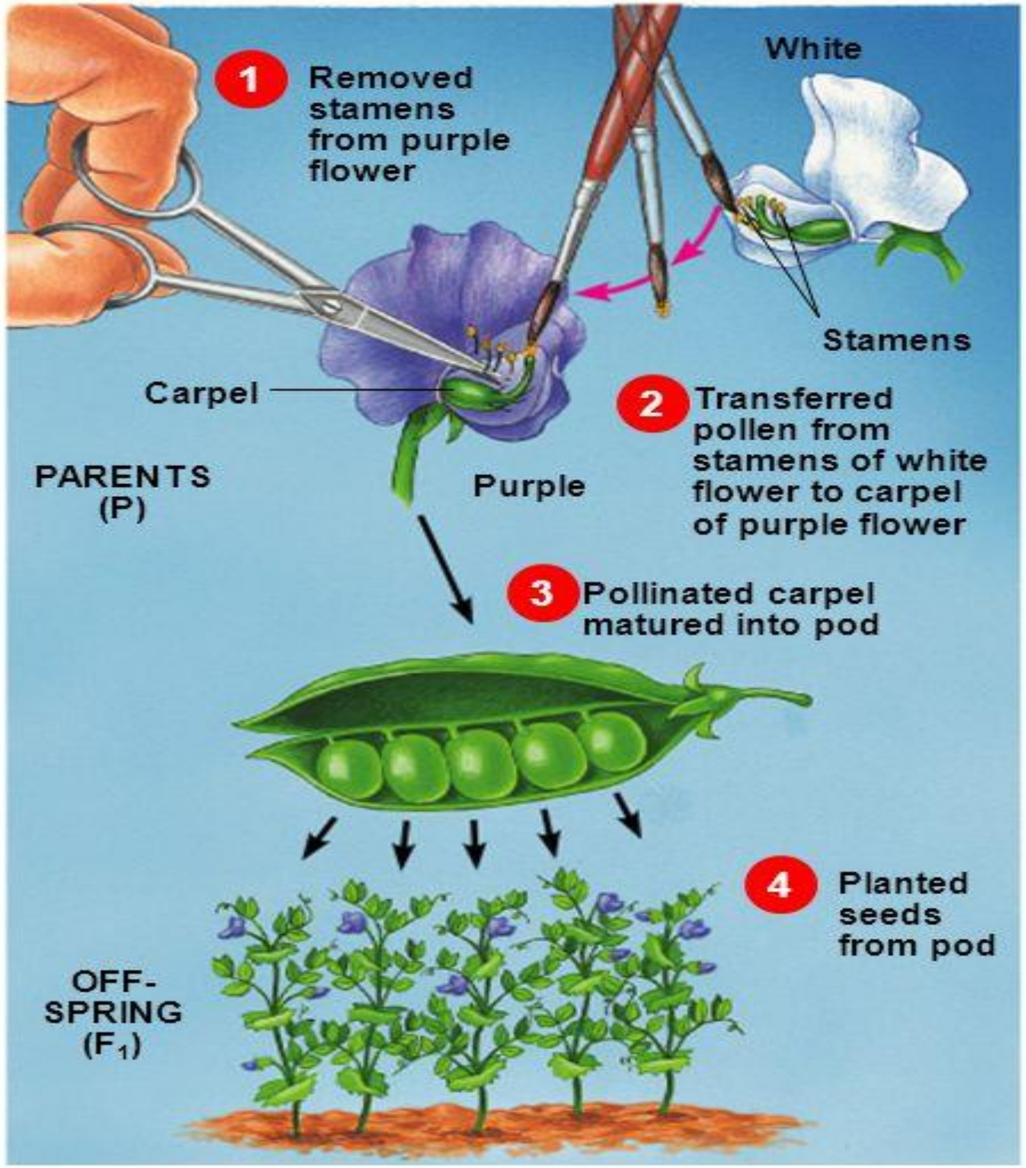
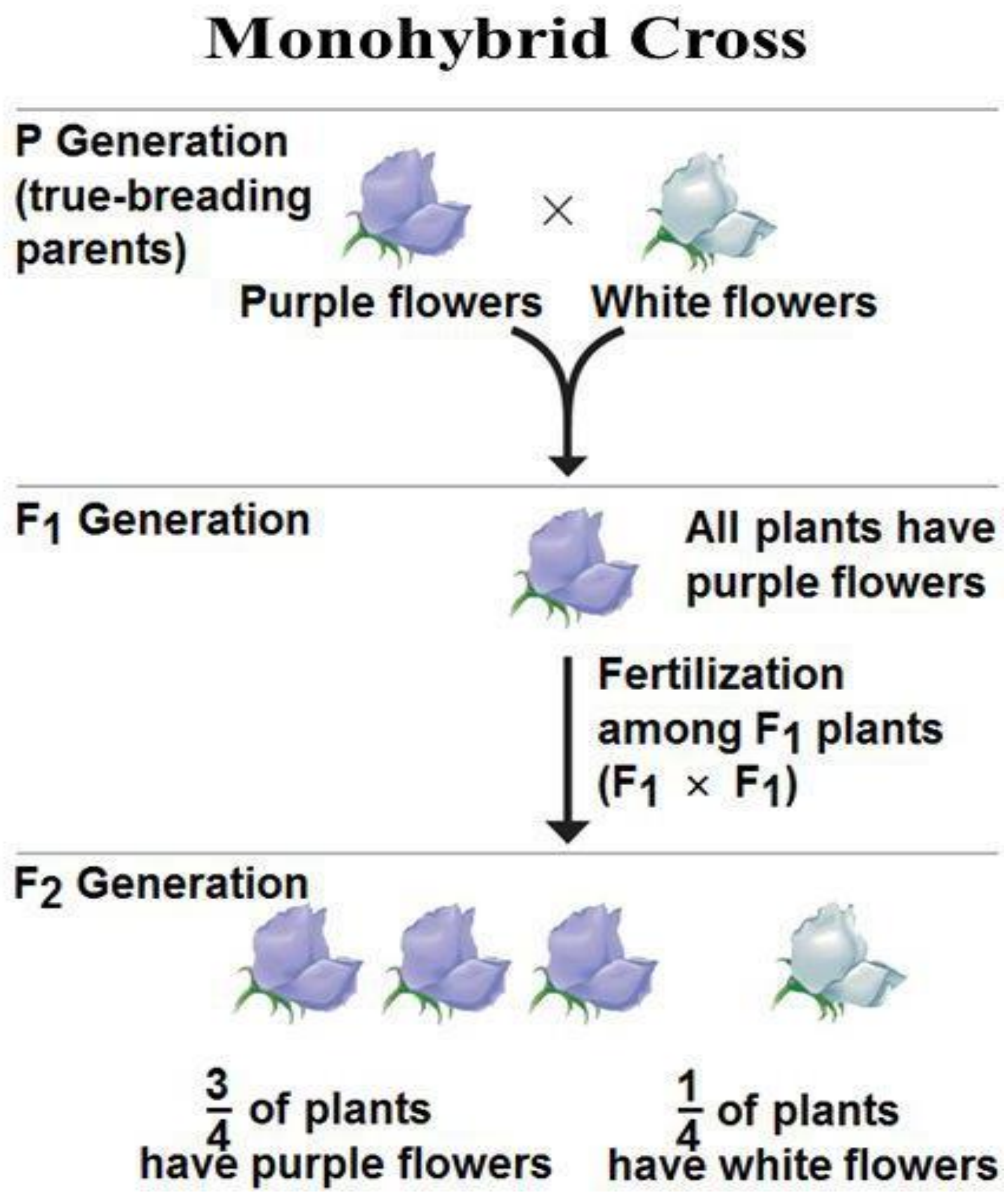


Figure 9.2C

Monohybrid Cross

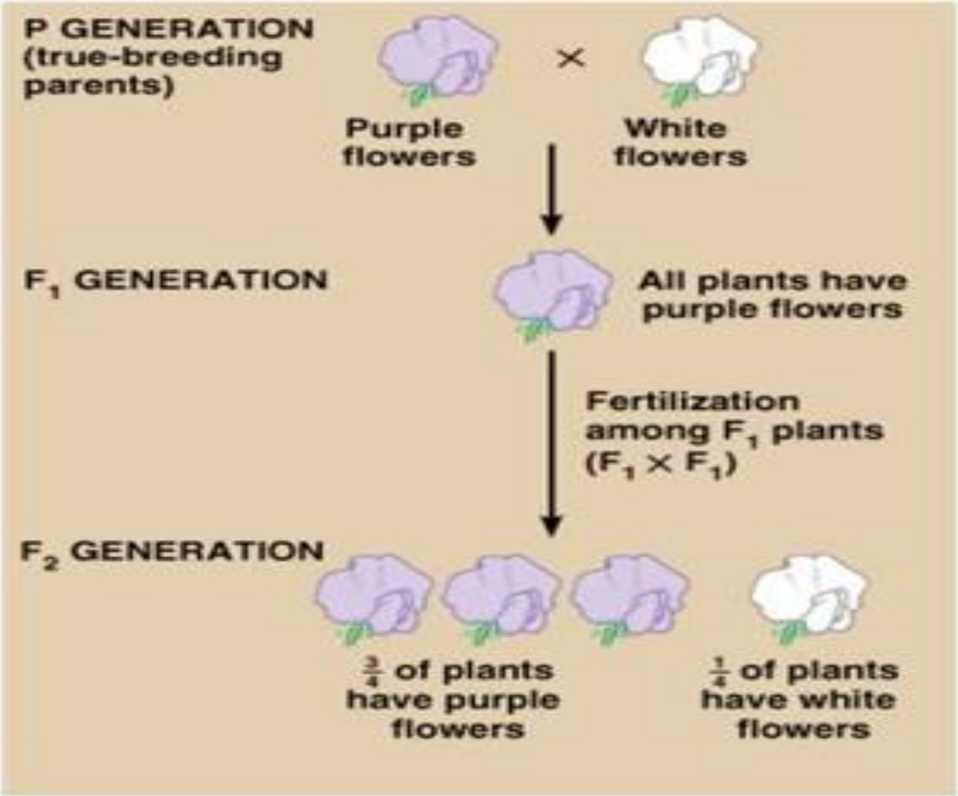
- **A monohybrid cross** is a cross between purebred parents that differ in only one characteristic
- **F1 generation:** all show the trait of one parent (i.e. purple flowers)
- **F2 generation:** show the two traits of the parents in a 3:1 ratio (i.e. purple to white flowers)

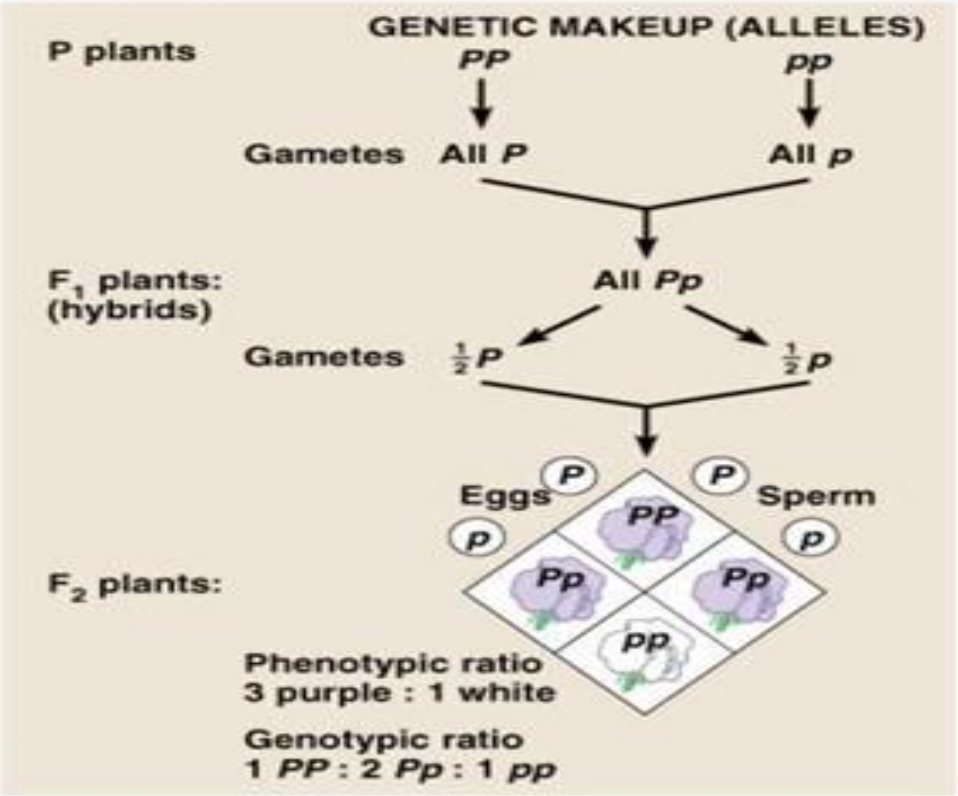


10.1 Mendel's Results from Monohybrid Crosses

	Parental Generation Phenotypes: Dominant		Parental Generation Phenotypes: Recessive		F1 Phenotypes	F_2 Generation Phenotypes: Dominant	F_2 Generation Phenotypes: Recessive	Total	Ratio
	Spherical seeds	×	Wrinkled seeds		Spherical	5,474	1,850	7,324	2.96:1
	Yellow seeds	×	Green seeds		Yellow	6,022	2,001	8,023	3.01:1
	Purple flowers	×	White flowers		Purple	705	224	929	3.15:1
	Inflated pods	×	Constricted pods		Inflated	882	299	1,181	2.95:1
	Green pods	×	Yellow pods		Green	428	152	580	2.82:1
	Axial flowers	×	Terminal flowers		Axial	651	207	858	3.14:1
	Tall stems (1 m)	×	Dwarf stems (0.3 m)		Tall	787	277	1,064	2.84:1

Results of Experiments





What you find here?

(A) Only one character appeared in the F1 generation

(B) Both characters were appeared in the F2 generation, but not in equal percentage

(C) A character which disappeared in the F1, reappeared in F2

(D) The results are consistent in all the seven characters

(E) There is no blending of characters

Law of Segregation (First law)

During the formation of gametes (eggs or sperm), the two alleles responsible for a trait separate from each other. Alleles for a trait are then "recombined" at fertilization, producing the genotype for the traits of the offspring.

It states that the two alleles for a character segregate (separate) when gametes (eggs or sperm), are formed

(Mendel was able to demonstrate that traits were passed from each parent to their offspring through the inheritance of factors (genes).)

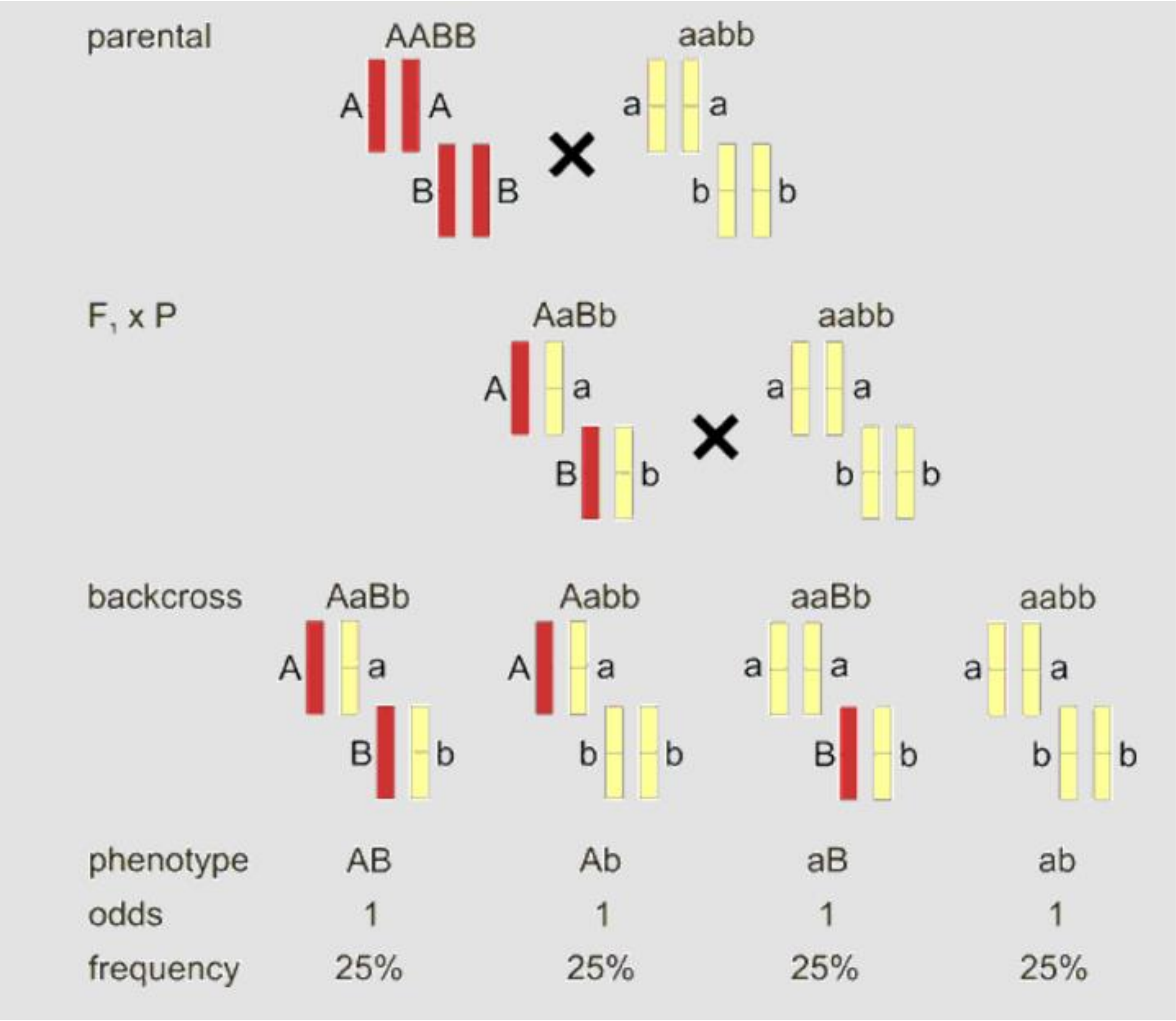
Back cross and test cross

Back Cross:

When F_1 individuals are crossed with one of the two parents from which they have been derived, then such a cross is called back cross.

two possibilities:

1) When F_1 (Cc) is crossed to the parent with dominant phenotype i.e., homozygous for red colour (CC). In such a cross plants will be 100% red.
2) When F_1 plant (Cc) is crossed to the parent with pure recessive (cc) white flowered plant. In such a cross 50% plants will be red flowered and 50% plants will be white flowered.



parental
AABB
A A
B B
aabb
a a
b b
F1 x P
AaBb
A a
B b
aabb
a a
b b
backcross
AaBb
A a
B b
Aabb
A a
b b
aaBb
a a
B b
aabb
a a
b b
phenotype AB Ab aB ab
odds 1 1 1 1
frequency 25% 25% 25% 25%

Test Cross:

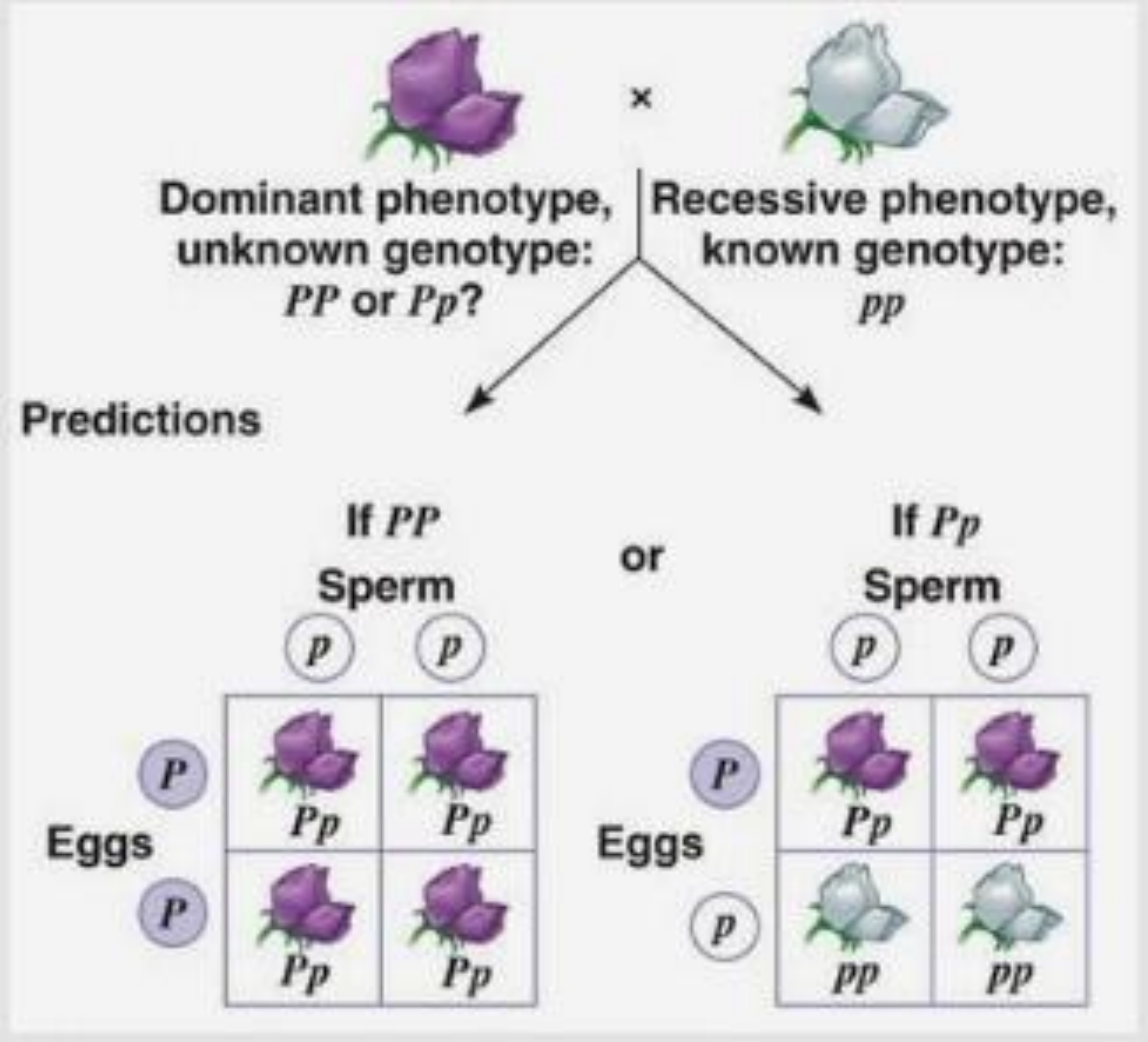
Test cross is the mating of a dominant phenotype (with unknown genotype CC or Cc) to a genotype which is homozygous recessive at all the loci under consideration

two possibilities:

1) When impure dominant (Cc) is crossed with the pure recessive (cc). In this cross 50% plants will be red and 50% will be white.
2) When pure dominant (CC) is crossed with a pure recessive (cc). In such a cross 100% plants will be red flowered.

Thus if we want to study whether the red flowered plants are homozygous or heterozygous we can take the help of a test cross.

- A monohybrid test cross of heterozygous dominant with pure recessive gives a 1: 1 phenotypic ratio.
- A di-hybrid test cross (of a heterozygous dominant with pure recessive) gives a phenotypic ratio of 1: 1: 1: 1


×
Dominant phenotype, unknown genotype: PP or Pp?
Recessive phenotype, known genotype: pp
Predictions
If PP
or
If Pp
Sperm
p
p
Eggs
P
P
Pp
Pp
Pp
Pp
Sperm
p
p
Eggs
P
p
Pp
Pp
pp
pp

Dihybrid Cross

Dihybrid Crosses: Crosses that involve 2 traits.

A cross between two parents that differ by two pairs of alleles (AABB x aabb)**,** This method can also work for any cross that involves two traits.

P: round, green **R/R; y/y** x wrinkled, yellow **r/r; Y/Y**

Gametes **R; y** **r; Y**

F1 All double heterozygous
dominant phenotype **R/r; Y/y**

F2 ?

Round dominant to Wrinkled, Yellow dominant to Green

Let's assume that the characters are transmitted together (which is not true, btw!), that is: **R** stays with **y**, while **r** stays with **Y**, as they were in parental gametes

P:	Round, green **R/R; y/y**	x	Wrinkled, yellow **r/r; Y/Y**
Gametes	**R; y**		**r; Y**
F1		Round, yellow **R/r; Y;y**	
Gametes		½ **R;y**	½ **r;Y**
F2			

	½ **R;y**	½ **r;Y**
½ **R;y**	¼ **R/R;y/y**	¼ **R/r; Y/y**
½ **r;Y**	¼ **R/r; Y/y**	¼ **r/r; Y/Y**

Then the prediction is: three classes and the ratio is1:2:1

¼ round, green R/R;y/y **½ round, yellow R/r;Y/y** **¼ wrinled, yellow r/r; Y/Y**

Or we can assume that the characters are transmitted independently. Then how many different types of gametes will we see in F1? Not two but four types!

P: Round, green **R/R; y/y** x Wrinkled, yellow **r/r; Y/Y**

Gametes: **R; y** **r; Y**

F1: Round, yellow **R/r; Y;y**

Gametes: ¼ **R;y** ¼ **R;Y** ¼ **r;y** ¼ **r;Y**

Why four types of gametes?

Probability of two independent events is a product of probabilities of the individual events.

According to Mendel Law I:
there must be ½ of gametes carrying Y and ½ of gametes carrying y, and also ½ of gametes carrying R and ½ of them carrying r.

If the presence of, say, R is independent of Y, then the probability (frequency) of gametes to carry both R and Y is ½ x ½ = ¼ . Similar ¼ of gametes with contain R and y, etc. , the total of four types of gametes with equal frequency of ¼ for each type.

Or we can assume that the characters are transmitted independently. Then how many different types of gametes will we see in F1? Not two but four types!

P: Round, green **R/R; y/y** x Wrinkled, yellow **r/r; Y/Y**

Gametes: **R; y** **r; Y**

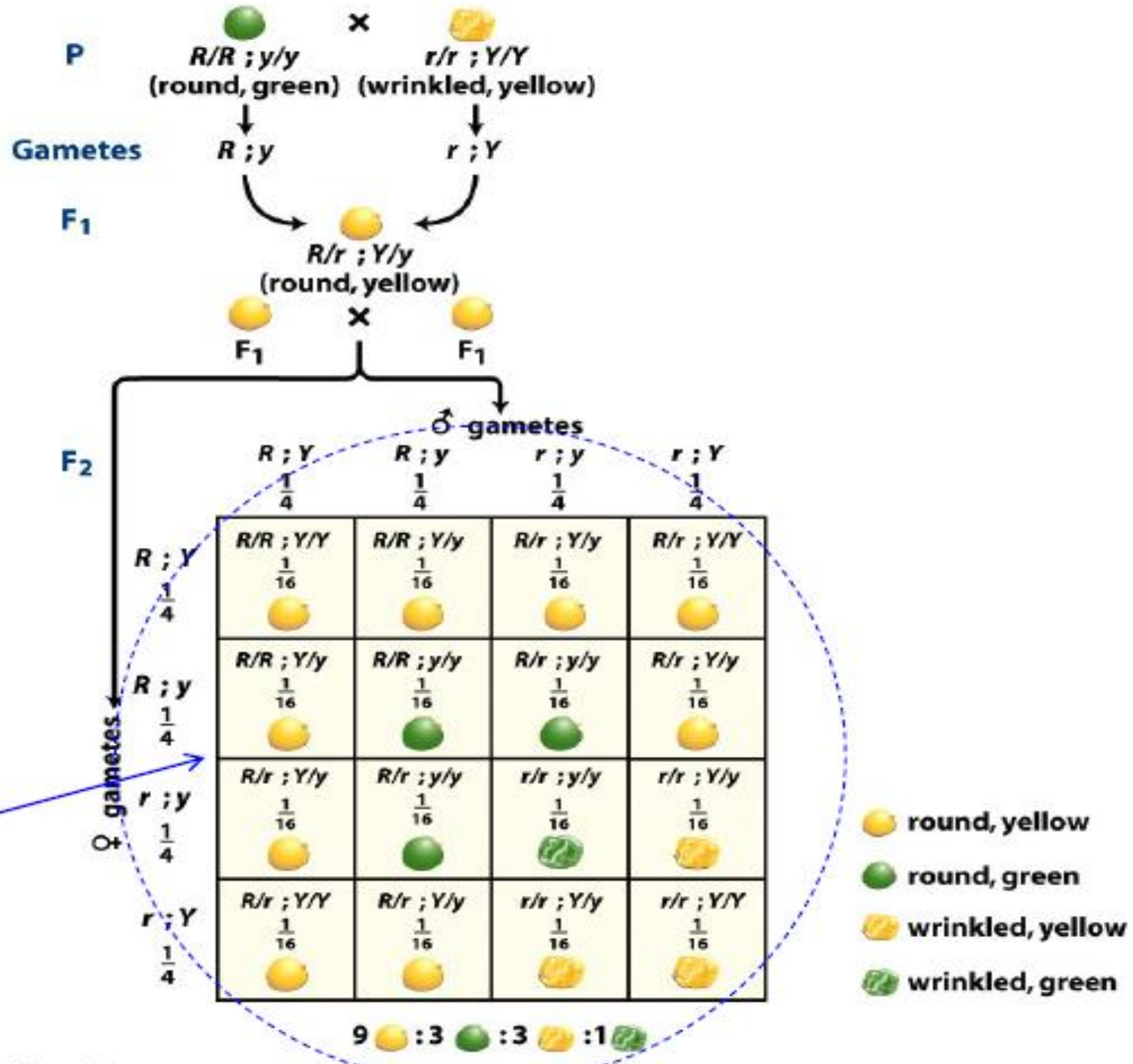
F1: Round, yellow **R/r; Y;y**

Gametes: ¼ **R;y** ¼ **R;Y** ¼ **r;y** ¼ **r;Y**

F2:

	¼ **R;y**	¼ **R;Y**	¼ **r;y**	¼ **r;Y**
¼ **R;y**				
¼ **R;Y**		How many classes?		
¼ **r;y**				
¼ **r;Y**				

Figuring out an outcome of a dihybrid cross using Punnett square



Punnett Square

Figure 3-4
Introduction to Genetic Analysis, Ninth Edition

Law of independent assortment (Second law)

- **Different pairs of alleles assort independently**

- during gamete formation assortment of alleles of one gene is independent of assortment of alleles of another gene

The hypothesis of independent packaging of alleles has been confirmed and thus become II Mendel's law

Branch diagram to calculate the genotypic ratio in the dihybrid cross

1:2:1	1:2:1	F_2 genotype	F_2 phenotype
	1/4 Y/Y	1/16 R/R;Y/Y	round, yellow
1/4 R/R	2/4 Y/y	2/16 R/R;Y/y	round, yellow
	1/4 y/y	1/16 R/R;y/y	round, green
	1/4 Y/Y	2/16 R/R;y/Y	round, yellow
2/4 R/r	2/4 Y/y	4/16 R/r;Y/y	round, yellow
	1/4 y/y	2/16 R/r;y/y	round, green
	1/4 Y/Y	1/16 r/r;Y/Y	wrinkled, yellow
1/4 r/r	2/4 Y/y	2/16 r/r;Y/y	wrinkled, yellow
	1/4 y/y	1/16 r/r;y/y	wrinkled, green
		9 classes	**4 classes**