GENETICS علم الوراثة

The study of hereditary and variations is called as Genetics

Core Concepts

- **Genes:** These are the basic units of heredity, made of DNA, that contain the instructions for building and maintaining an organism. You inherit two copies of every gene—one from each biological parent.
- **Alleles:** An allele is one of two or more variant forms of a gene found at the same place, or locus, on a chromosome. Organisms that reproduce sexually inherit two alleles for each gene, one from each parent. **Different versions of the same gene, like the gene for flower color.** The purple allele is typically represented with a capital "P," while the recessive white allele is represented with a lowercase "p".
- **DNA:** Genes are segments of a larger molecule called deoxyribonucleic acid (DNA). It is the unique DNA sequence that acts as the genetic blueprint.

- **Heredity:** This is the process of passing genetic information and traits, such as eye color and blood type, from one generation to the next.
- **Genotype:** The combination of alleles an organism inherits is its genotype.
- **Homozygous:** If both inherited alleles are the same (e.g., both code for blue eyes), the organism is homozygous for that trait.
- **Heterozygous:** If the inherited alleles are different (e.g., one codes for brown eyes and the other for blue eyes), the organism is heterozygous for that trait.
- **Phenotype:** The physical trait that an allele combination produces is called the phenotype. In this case, the purple flower color is the dominant phenotype, and the white flower color is the recessive phenotype.

Dominant and recessive alleles

The relationship between two alleles determines how the trait is expressed:

- **Dominant allele:** This allele will be expressed in the phenotype even if only one copy is present (in a heterozygous pair).
- **Recessive allele:** This allele is masked by a dominant allele and is only expressed when two copies of it are present.

Examples of alleles

- **Eye color:** The gene for eye color has several alleles, including those for brown and blue eyes. The allele for brown eyes is dominant over the allele for blue eyes.
- **Pea plant color:** In Gregor Mendel's classic experiments, alleles for flower color resulted in either purple or white flowers. The allele for purple flower color is dominant over the allele for white flower color. This means that a plant only needs one copy of the dominant purple allele to have purple flowers.

Classical / Mendelian Genetics

- Genetics is the scientific study of **heredity**.

هو العلم الذي يدرس المورثات (الجينات) وانتقال ما تحمله من صفات.. الدراسة العلمية للورثة.

- Gregor Mendel (1860's) an Austrian Monk, was interested in figuring out how heredity was determined in plants and animals.
  - used pea plants
  - **quantitative** approach to collect data.

- Mendel studied seven different pea plant **traits**.
  - Seed shape & color, pod shape & color, plant height, flower color and seed coat color

- A **trait** is a specific characteristic, such as seed color or plant height, that varies from one individual to another.

Gregor Mendel: Father of Genetics

Gregor Mendel's Experiment

Character	Contrasting traits	
Seed shape	round/wrinkled	
Seed color	yellow/green	
Pod shape	full/constricted	
Pod color	green/yellow	
Flower color	violet/white	
Flower position	axial/terminal	
Stem height	tall/dwarf	

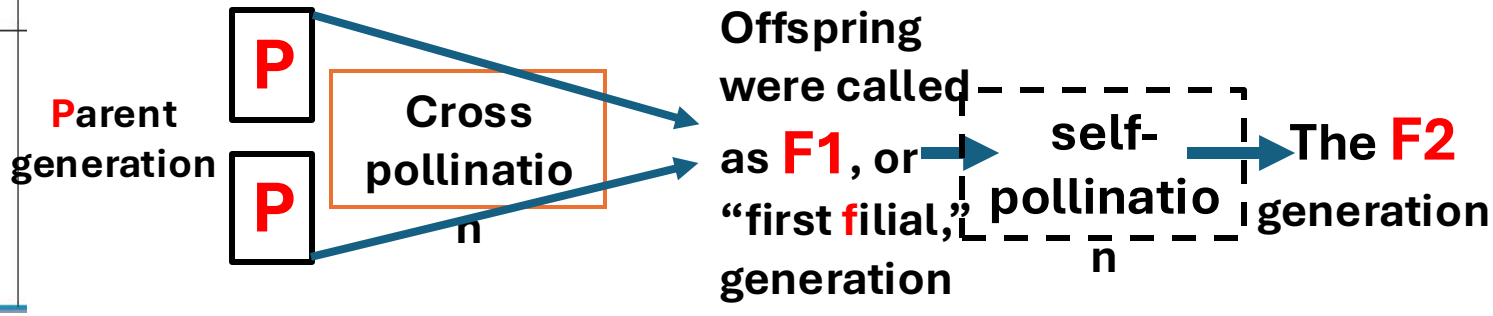
Seven pairs of contrasting traits selected by Mendle

Monohybrid cross is a cross between two individual having single contrasting traits.

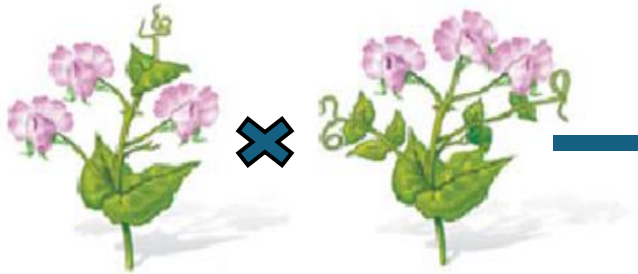
Dihybrid cross is a cross between two individual having two different traits.

Cross pollination التلقيح الخلطي The transfer of pollen from an anther of a flower of one plant to a stigma of a flower of another plant) self-pollination التلقيح الذاتي(on the same plant).

The offspring of crosses between parents with different traits are called hybrids ويطلق على الذرية الناتجة من التلقيح الخلطي بين الآباء مختلفي الصفات (الهجينة).



Seven pairs of contrasting traits and the results of Mendel's seven monohybrid crosses of the garden pea

Character	Contrasting traits		F_1 results	F_2 results	F_2 ratio
Seed shape	round/wrinkled		all round	5474 round 1850 wrinkled	2.96:1
Seed color	yellow/green		all yellow	6022 yellow 2001 green	3.01:1
Pod shape	full/constricted		all full	882 full 299 constricted	2.95:1
Pod color	green/yellow		all green	428 green 152 yellow	2.82:1
Flower color	violet/white		all violet	705 violet 224 white	3.15:1
Flower position	axial/terminal		all axial	651 axial 207 terminal	3.14:1
Stem height	tall/dwarf		all tall	787 tall 277 dwarf	2.84:1

MONOHYBRID CROSSES: THE PRINCIPLES OF DOMINANCE AND SEGREGATION

Results of Mendel's F1 Crosses:

When Mendel crossed plants with contrasting characters for the same trait (for example All round), the resulting offspring had only one of the characters in F1 generation.

P	Round  Wrinkled	Yellow  Green	Gray  White	Smooth  Constricted	Green  Yellow	Axial  Terminal	Tall  Short
F_1	 Round	 Yellow	 Gray	 Smooth	 Green	 Axial	 Tall

But the population of F1 generation self pollinated, the resulting offspring had characters of two different traits 3: 1 (F2 ratio) . From these, Mendel concluded that:

- Each **Phenotype** (traits or morphological characters to which we can see) of an organism is governed by a specific Factor
- Each organism has 2 factors for each of traits (Factors = Allelles = Genes), one trait is dominant and other trait is recessive . Or it may be said that one factor Is **dominant** and other factor is **recessive**.
- The two factors segregates at the time of gamete formation

Mendel's conclusions: Rules

1. Rule of Unit Factors

Each organism has 2 factors for each of its traits (alleles: gene alternatives)

كل كائن حي لديه 2 من العوامل لكل صفة من صفاته واحد من الأب واخر من الأم.
(**الأليلات**: اشكال مختلفة من الجينات).

2. Rule of Dominance قانون السيادة

For each trait there exists 2 possible factors that are expressed in physical characters, one that may be dominant, and the other recessive.

لكل صفة 2 من العوامل يتم التعبير عنهما في الصفات الطبيعية، احدهما قد تكون سائد والآخر المتنحية.

3. Law of Segregation قانون انعزال السمات

The two alleles for each trait must separate when gametes form.

الاليلين الخاصة لكل صفة تنعزل (تنفصل) عند تشكيل الأمشاج.

Expression of Traits ظهور الصفة

1. phenotype:

physical expression of a gene

الطراز المظهري (النمط الظاهري): التعبير الظاهري للجين
(أي الصفة التي يظهرها الجين على الشكل الظاهري للكائن مثل اللون او الطول

2. genotype:

a make of genes on a chromosome

الطراز الجيني (النمط الجيني): بناء او وضعية الجينات على الكروموسوم مثل YY

3. homozygous:

alleles for a trait are the same

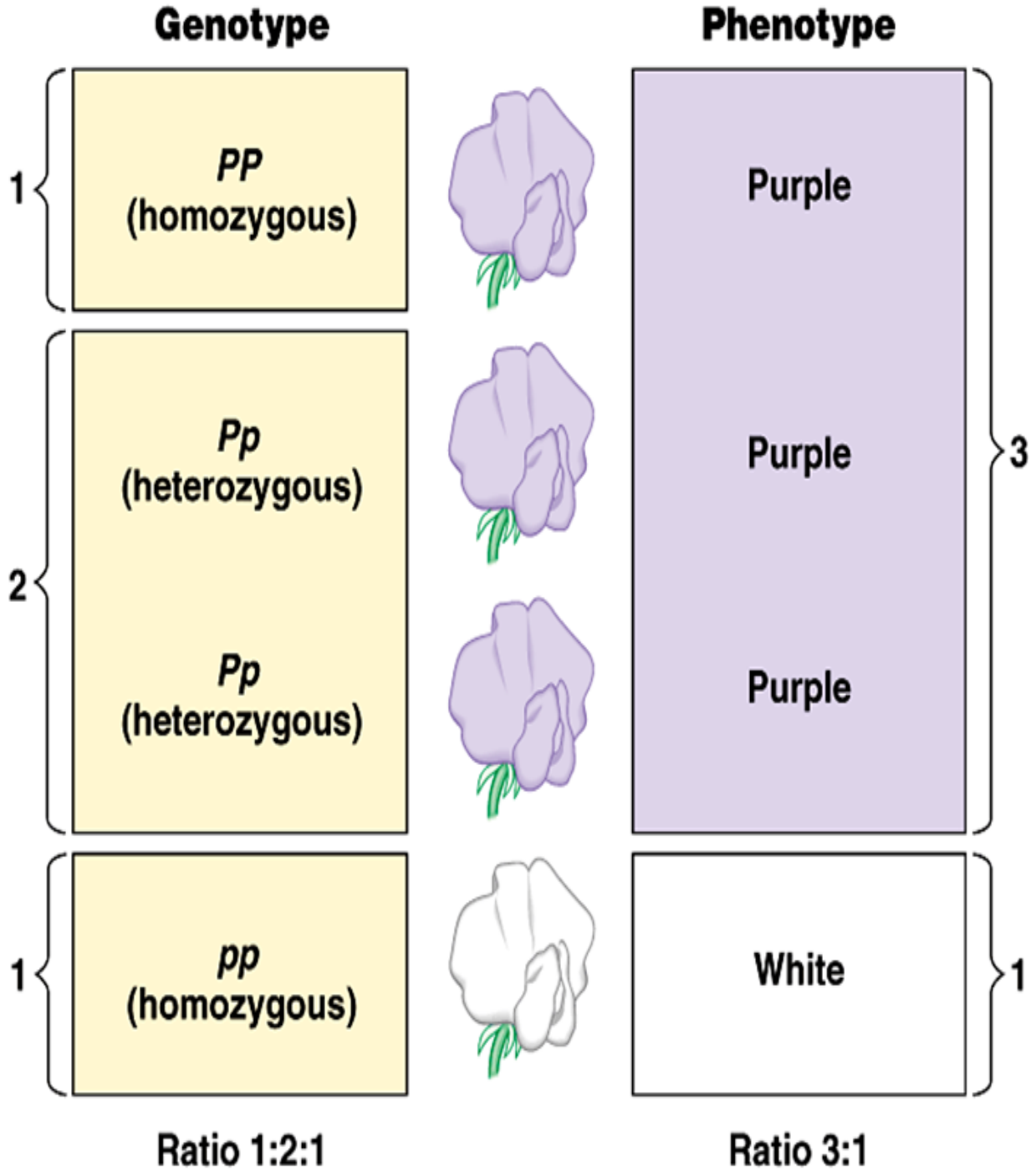
متماثل الجينات: الأليلات لسمة ما (لصفة ما) هي نفسها مثل YY

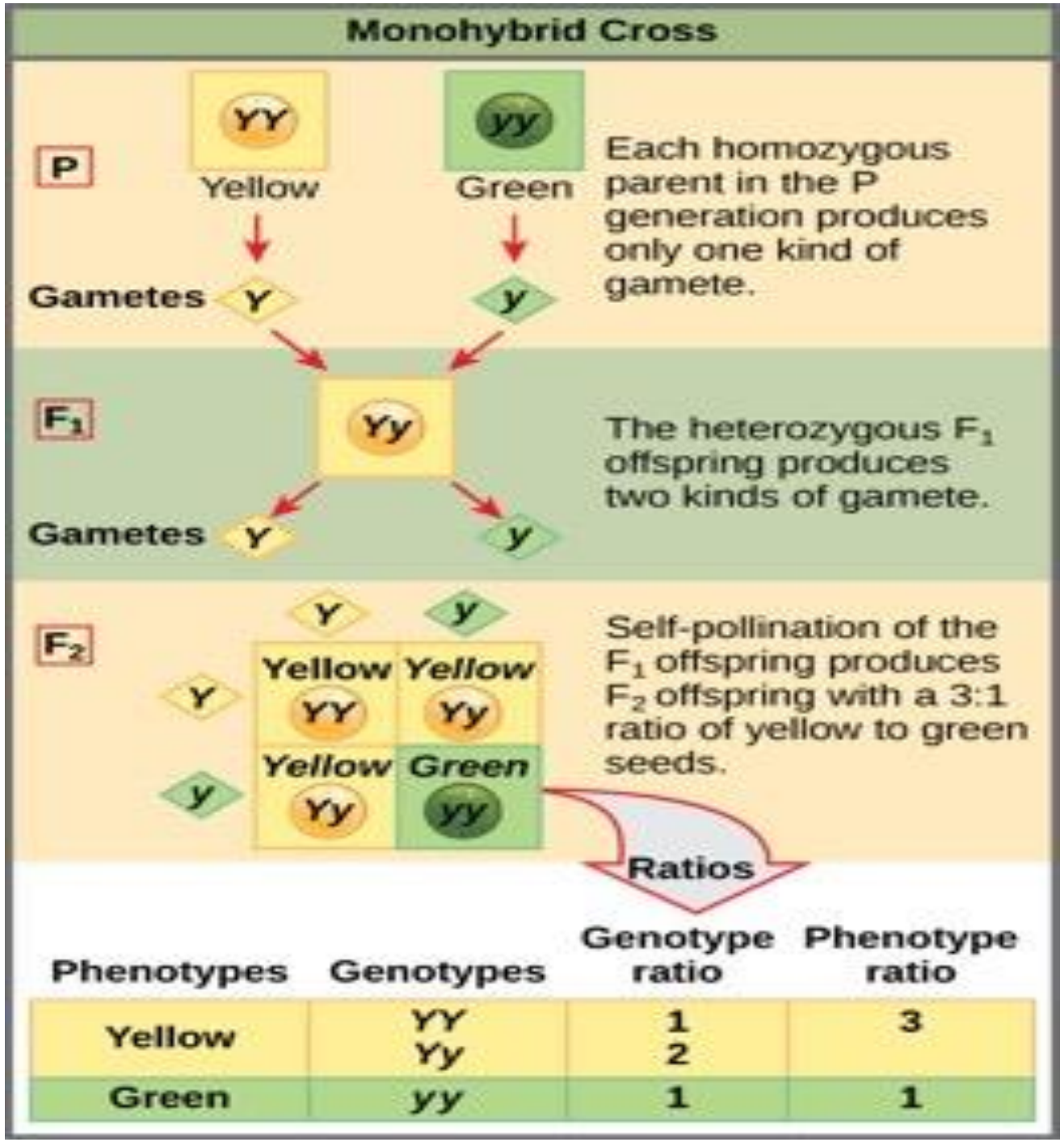
4. heterozygous:

alleles for a trait are opposite

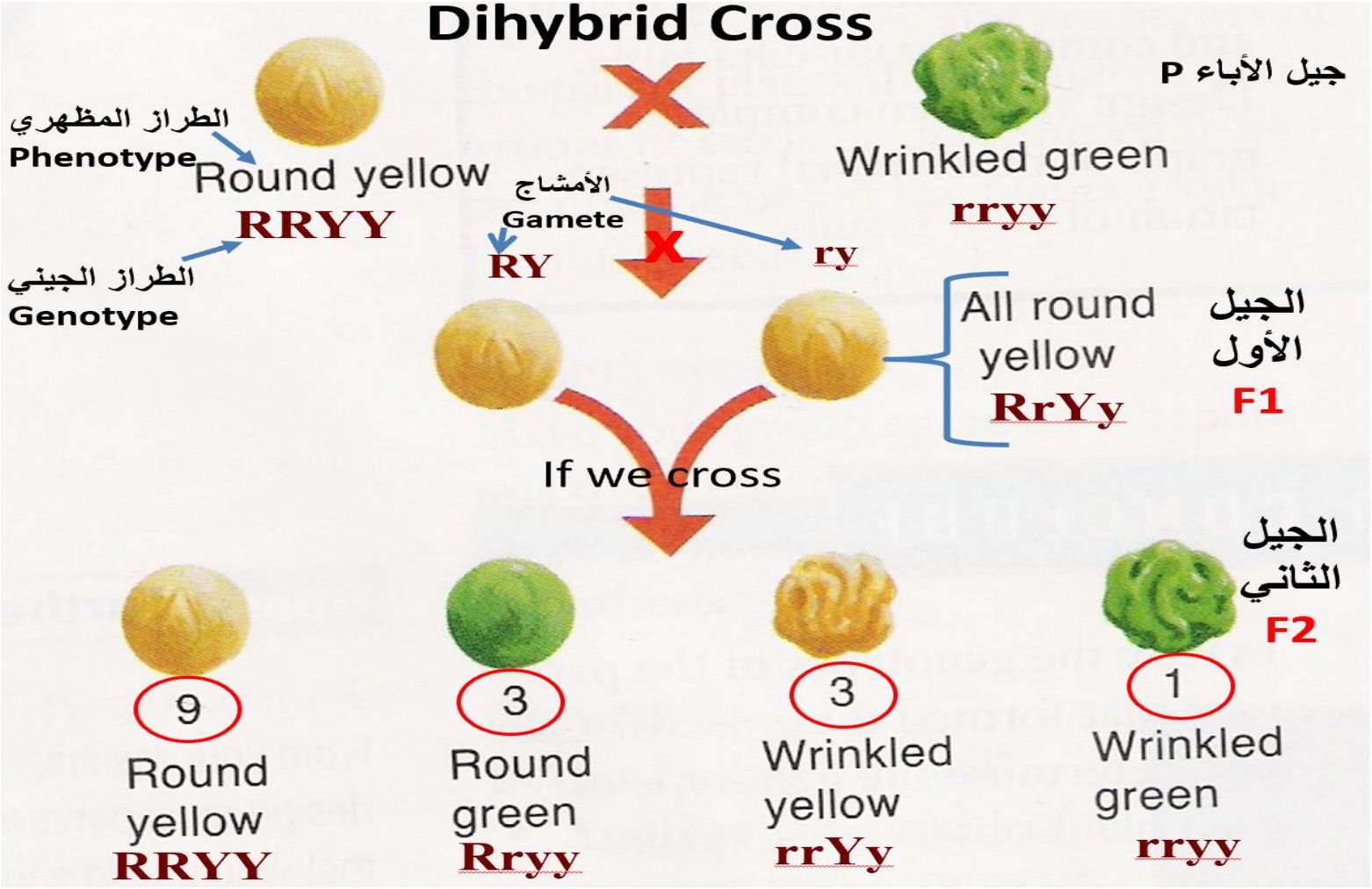
متباين الجينات: الأليلات لسمة ما مختلفة مثل Yy

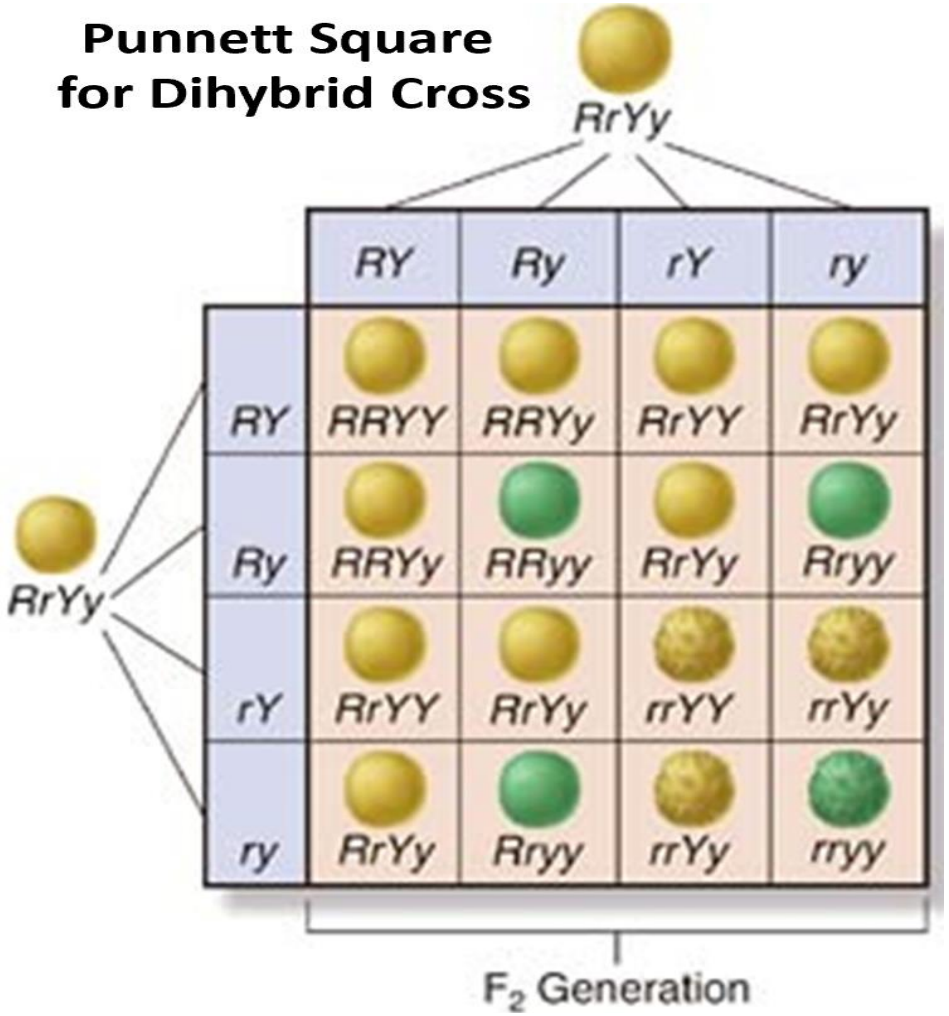
- Genotypes
- Homozygous = same alleles = PP, *pp*
- Heterozygous = different alleles = P*p*





Phenotypes	Genotypes	Genotype ratio	Phenotype ratio
Yellow	YY Yy	1 2	3
Green	yy	1	1





- F_1 generation produced all round yellow seeds
- F_2 generation produced :
  - 9 round yellow
  - 3 round green
  - 3 wrinkled yellow
  - 1 wrinkled green

Punnett Square for Dihybrid Cross

(Cross between 2 parents that are Heterozygous for two traits)

Round Yellow Seeds X Round Yellow Seeds

RrYy X RrYy

Law of Independent assortment –

- different traits are passed independently of each other. OR
- Genes for different traits are inherited independently of each other.
- All possible combinations of gametes with the two traits must be considered possible.

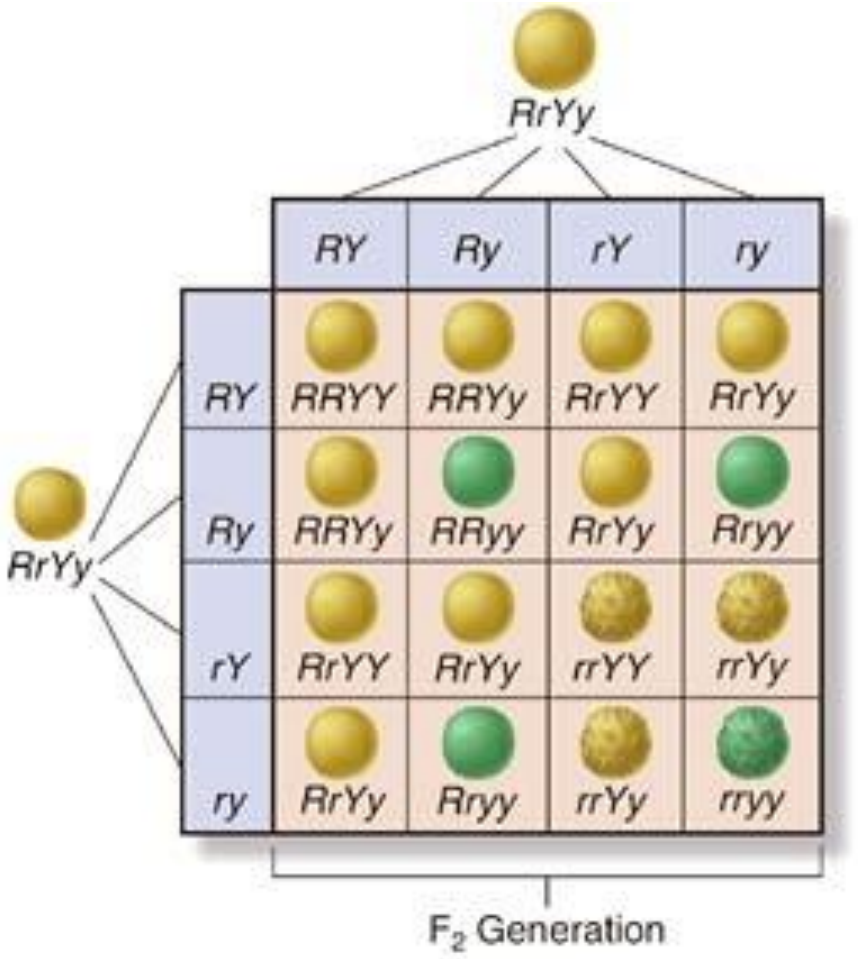
قانون التوزيع الحر: يتم توريث الصفات المختلفة بشكل مستقل عن بعضها البعض

بمعنى إذا تزاوج فردان يختلفان في أكثر من زوج من الصفات المتضادة فإن كل زوج من الجينات الخاصة بهذه الصفات يتوزع توزيعاً حراً ومستقلاً عند تكوين الجاميتات

Did this mean that the two dominant alleles would always stay together?

When Mendel let the F_1 self pollinate, he got a definite ratio of visible phenotypes:

- **9** with both dominant (RY)-Round Yellow
- **3** one dominant and one recessive (Ry)-round green
- **3** one recessive and one dominant (rY) – wrinkled yellow
- **1** both recessive (rryy) - wrinkled green



عندما ترك مندل F1 يلقح ذاتيا، وحصل على نسبة محددة من الطراز المظهري:

MONOHYBRID CROSSES:

Conclusions/ Rules:

The principles of Dominance and Segregation

From these, Mendel concluded that:

- Each Phenotype (traits or morphological characters to which we can see) of an organism is governed by a specific Factor
- Each organism has 2 factors for each of traits (Factors = Allelles = Genes), one trait is dominant and other trait is recessive . Or it may be said that one factor Is dominant and other factor is recessive.

DIHYBRID CROSSES:

Conclusions/ Rules:

The Law of segregation or Independent Assortment

- The two dominant and recessive factors remains in a pair but segregates at the time of gamete formation

تمارین

P_1 Monohybrid Cross

Trait: Seed Shape

Alleles: R – Round r – Wrinkled

Cross: **Round** seeds x **Wrinkled** seeds

RR x rr

Rr -----F1

Selfing

	r	r
R	Rr	Rr
R	Rr	Rr

Genotype: Rr

Phenotype: Round

Genotypic Ratio: All alike

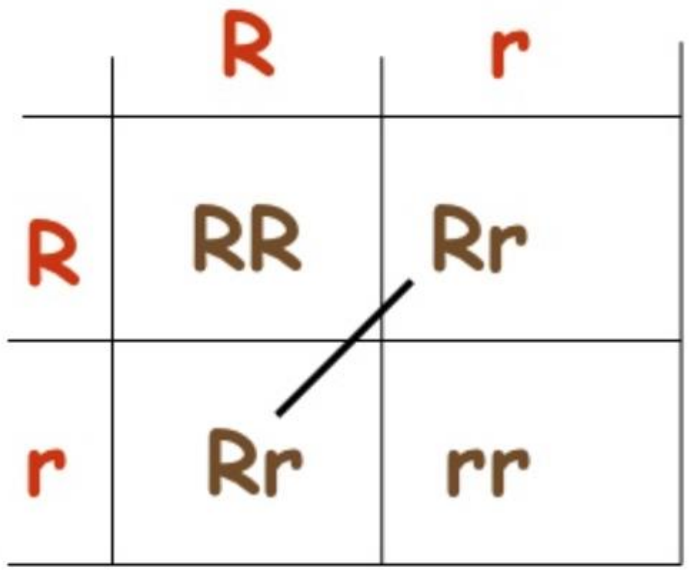
Phenotypic Ratio: All alike

P_1 Monohybrid Cross Review

- Homozygous dominant x Homozygous recessive
- Offspring all Heterozygous (hybrids)
- Offspring called F_1 generation
- Genotypic & Phenotypic ratio is ALL ALIKE

F_1 Monohybrid Cross

- Trait: Seed Shape
- Alleles: R – Round r – Wrinkled
- Cross: Round seeds x Round seeds
- Rr x Rr



Genotype: RR, Rr, rr

Phenotype: Round & wrinkled

G.Ratio: 1:2:1

P.Ratio: 3:1

How to Make a Punnett Square

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

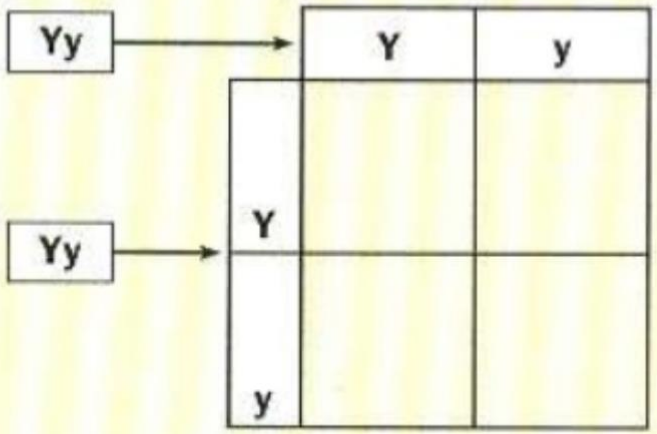
In this example, both parents are heterozygous for yellow-pea allele (*Yy*).

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.

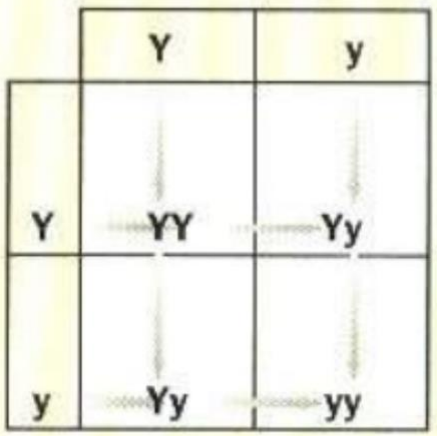
Parent 1

Parent 2



2 Fill in the grid

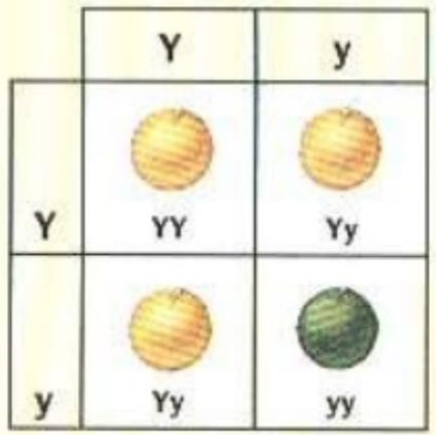
Combine the parent alleles inside the boxes. The letters show the genotypes of the offspring.



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.

Question:

الصفات النوعية الصفات الكمية

1. What is the difference between the Qualitative and quantitative traits ?

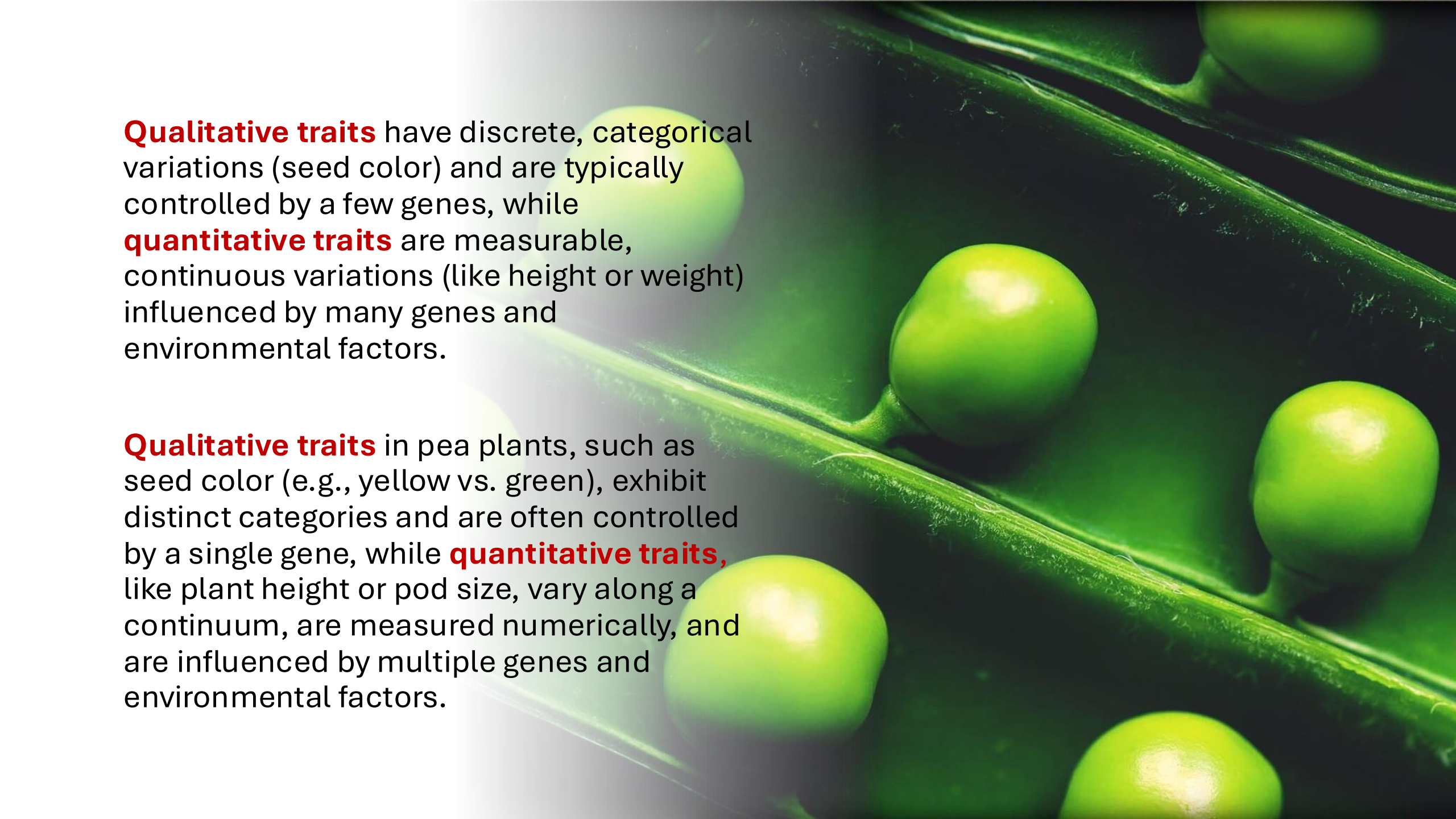
2. If you have a tall wheat plant (TT) and you crossed it with another short cultivar (tt)what the probabilities of having a tall plants at the second generation F2?

TT X tt --- Tt f1

Self Tt x Tt

Qualitative traits have discrete, categorical variations (seed color) and are typically controlled by a few genes, while **quantitative traits** are measurable, continuous variations (like height or weight) influenced by many genes and environmental factors.

Qualitative traits in pea plants, such as seed color (e.g., yellow vs. green), exhibit distinct categories and are often controlled by a single gene, while **quantitative traits,** like plant height or pod size, vary along a continuum, are measured numerically, and are influenced by multiple genes and environmental factors.



Qualitative Traits

Distinct Categories: These traits fall into clear, separate groups with no intermediate forms.

Single-Gene Control: Often, a single gene with two alleles controls the expression of a qualitative trait, adhering to Mendelian inheritance patterns.

Examples in Pea Plants:

- **Seed Color**: Yellow seeds vs. green seeds.
- **Seed Shape**: Smooth seeds vs. wrinkled seeds.
- **Flower Color**: White flowers vs. violet flowers.
- **Pod Color**: Green pods vs. yellow pods.

Quantitative Traits

- **Continuous Variation**: These traits show a wide range of variation, forming a continuum rather than distinct categories.
- **Polygenic Inheritance**: Quantitative traits are typically controlled by many genes (polygenic), with each gene contributing a small effect to the overall phenotype.
- **Environmental Influence**: Environmental conditions can also significantly impact the development of quantitative traits.
- **Numerical Measurement**: To describe these traits, numerical measurements are required using tools like rulers or scales.
- **Examples in Pea Plants**:
  - **Plant Height**: A pea plant's height can vary along a continuous scale.
  - **Pod Length**: The size of a pea pod can differ, falling into a range of sizes.
  - **Number of Pods**: A plant could produce a variable number of pods, from a few to many.