

Mendelian Genetics



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المزيد من مادة
علوم:

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التواصل الاجتماعي بحسب الصف الحادي عشر العام



صفحة المناهج
الإماراتية على
فيسبوك

الرياضيات

اللغة الانجليزية

اللغة العربية

التربية الاسلامية

المواد على تلغرام

المزيد من الملفات بحسب الصف الحادي عشر العام والمادة علوم في الفصل الثالث

الأنماط الأساسية للوراثة البشرية

1

ارتباط الجينات وتعدد المجموعات الكروموسومية

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علم الوراثة المندلية

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الانقسام المنصف

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انسباير منهج Cellular Energy - Solution Paper

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الأحياء

BIOLOGY





How Genetics Began

In 1866, **Gregor Mendel**:

- an Austrian monk
- a plant breeder

راهب نمساوي
يحب يشتغل في الزراعة او مربى نباتات

he published his findings on the method of inheritance in garden pea plants. The passing of traits (الصفات) to the next generation is called **inheritance**, or **heredity**.

Mendel (**Figure 1**) was successful in solving the mystery of inheritance because of the organism he chose for his study — **the pea plant**.

Pea plants are **true-breeding**, meaning they consistently produce offspring with only one form of a trait.

الصفات بتفضل ثابتة في النسل

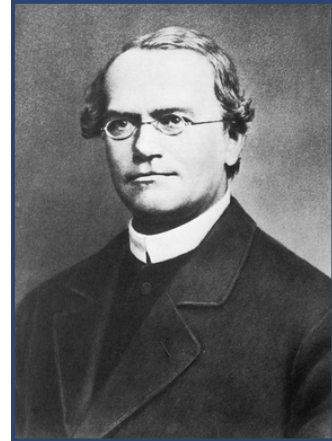


Figure 1: Gregor Mendel is known as the father of genetics

Reproduction in Pea Plants

Pea plants usually reproduce by self-fertilization¹, which is common in many flowering plants.

Self-fertilization occurs when a male gamete within a flower combines with a female gamete in the same flower.

Mendel discovered that pea plants could also be cross-pollinated² by hand.

He performed cross-pollination by:

1. Transferring a male gamete from the flower of one pea plant
2. To the female reproductive organ in a flower of another pea plant

History Connection

Mendel:

1. Rigorously followed traits in the pea plants he bred
2. Analyzed the results of his experiments
3. Formed hypotheses about how traits were inherited

تابع الصفات بدقة في كل نبات بازلاء
وسجل كل نتيجة بالأرقام (لا مجرد ملاحظة)
ثم بدأ يفكر ويسأل ويضع فرضية
لماذا تظهر الصفات بهذه الصورة؟ أين يكمن النظام؟

This led to the study of genetics, the science of heredity.

وقد أدى ذلك إلى نشوء علم الوراثة، وهو العلم الذي يدرس الموروثات (التوارث)

Mendel is regarded as the father of genetics.

**EXTRA**

Genetics :The scientific study of heredity and how traits are passed from parents to offspring.

علم الوراثة: هو العلم الذي يفسر كيف أن الصفات تنتقل من جيل لجيل

Heredity :The process by which traits are passed from parents to their children.

الوراثة: هي انتقال الصفات من الآباء للأبناء بشكل طبيعي

Trait: specific inherited characteristic, such as eye color, height, or flower shape.

الصفة الوراثية: حاجة بتظهر في الشكل أو الوظيفة وبتتورث زي لون العين أو الطول

**The Inheritance of Traits**

Mendel noticed that certain varieties of garden pea plants produced specific forms of a trait, generation after generation.

For instance, he observed that:

- Some varieties always produced green seeds
- Others always produced yellow seeds

To understand how these traits are inherited, Mendel performed **cross-pollination** by:

1. Transferring male gametes from the flower of a true-breeding green-seed plant
2. To the female organ of a flower from a true-breeding yellow-seed plant

To **prevent self-fertilization**, Mendel:

- Removed the male organs from the flower of the yellow-seed plant

Mendel called the green-seed plant and the yellow-seed plant the parent generation — also known as the **P generation**.

F₁ and F₂ Generations

When **Mendel** grew the seeds from the cross between the green-seed and yellow-seed plants,
→ all the resulting offspring had yellow seeds.

The offspring of this P (parent) cross are called the first **filial (F₁) generation**.

The green-seed trait seemed to disappear in the F₁ generation,

and **Mendel** wanted to know whether the trait was:

- No longer present
- Or simply hidden (masked)



Mendel then:

1. Planted the F₁ yellow seeds
2. Allowed the plants to grow and self-fertilize
3. Examined the seeds from this second cross

The results of the second filial (F₂) generation — the offspring from the F₁ cross — are shown in **Figure 2**.

Results:

- Out of the seeds Mendel collected:
6022 were yellow
2001 were green
- This is almost a perfect **3:1** ratio of **yellow** to **green** seeds



N.B

Mendel studied seven traits:

- Seed (pea) color → لون البذور (البازلاء)
- Flower color → لون الزهرة
- Seed pod shape → شكل القرن (منتفخ أو منضغط)
- Stem length → طول الساق (طويل أو قصير)
- Seed pod color → لون الغلاف (القرن) الذي يحمل البذور
- Seed shape or texture → شكل أو ملمس البذور (ناعمة أو مجعدة)
- Flower position → موضع الزهرة (طرفية أو جانبية)

He found that the F₂ generation from these crosses also showed a 3:1 ratio.

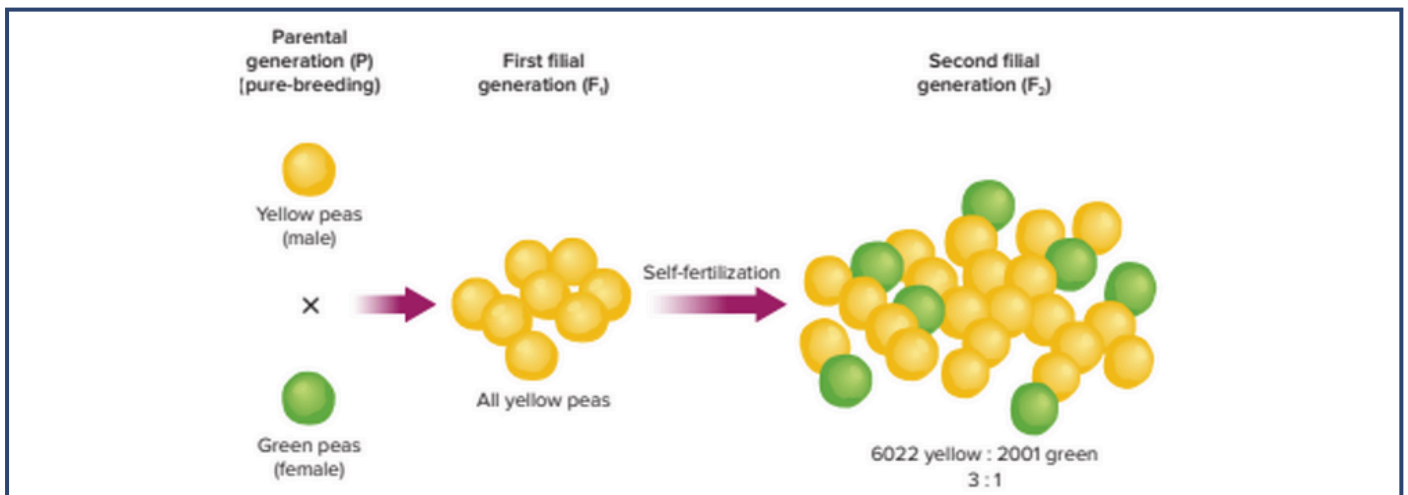


Figure 2

The results of Mendel's cross involving true-breeding pea plants with yellow seeds and green seeds are shown here.

Explain why the seeds in the F₁ generation were all yellow?

Because the yellow seed trait is dominant, and the green trait is recessive.

So when Mendel crossed a pure yellow with a pure green plant, all offspring in the F₁ generation inherited one dominant yellow gene and one recessive green gene — but only the dominant yellow trait appeared.



Genes in Pairs

Mendel concluded that there must be two forms of the seed trait in pea plants:

– Yellow-seed

– Green-seed

Each form was controlled by a factor — now called an allele.

Allele = an alternative form of a single gene passed from generation to generation

So, the gene for yellow seeds and the gene for green seeds are **different forms of the same gene**.

Mendel concluded that the 3:1 ratio could be explained if:

The alleles were paired

One allele could mask the other

He gave names to these:

The trait that appeared in the F₁ generation → **Dominant**

The trait that was masked in the F₁ generation → **Recessive**

Final conclusion:

In the cross, the yellow seed was dominant,
and the green seed was recessive.

Dominance

When Mendel allowed the F₁ generation to self-fertilize, he showed that the recessive allele for green seeds had not disappeared.

Mendel concluded:

- The green seed trait did not show up in the F₁ generation
- Because the yellow-seed form of the trait is dominant
- When the dominant allele is present, it masks the allele for the green-seed form

When modeling inheritance:

1. The **dominant** allele is represented by a **capital letter**
2. The **recessive** allele is represented by a **lowercase letter**

Types of allele combinations:

• **Homozygous = an organism with two of the same alleles for a trait**

• Example:

– Yellow-seed plants = YY

– Green-seed plants = yy

• **Heterozygous = an organism with two different alleles for a trait**

• Example:

– A plant with seed color Yy

When alleles are in the heterozygous state:

- The **dominant** trait appears
- The **recessive** trait is masked



Genotype and Phenotype

1. Possibilities for a yellow-seed plant's genotype

- Could be homozygous (YY).
- Could be heterozygous (Yy).
- An organism's appearance does not always indicate which alleles are present.

2. **Phenotype (definition)** : Observable characteristic or outward expression of an allele pair.

- Example: Genotype yy → Phenotype = green seeds.

3. **Genotype (definition)** : The organism's allele pairs.

- Examples:
 - Yellow-seed plant genotype = YY or Yy.
 - Green-seed plant genotype = yy.



Mendel's Laws

Mendel used his results to develop:

- The law of segregation
- The law of independent assortment

These laws help analyze patterns of inheritance.

Law of Segregation

Mendel used homozygous **yellow-seed** and **green-seed** plants in his P cross.

In **Figure 3(A)**, the **top** drawing shows:

- Each gamete from the **yellow-seed plant** contains one Y allele
- (Chromosome number is halved during meiosis)
- Gametes contain only one of the pair of seed-color alleles

The **bottom** drawing in **Figure 3(A)** shows:

- Each gamete from the green-seed plant contains one y allele

Mendel's law of segregation states:

- The two alleles for each trait separate during meiosis
- During fertilization, two alleles unite for that trait

The **bottom** drawing in **Figure 3(A)** shows:

- Each gamete from the green-seed plant contains one y allele

Mendel's law of segregation states:

- The two alleles for each trait separate during meiosis
- During fertilization, two alleles unite for that trait

The third drawing in **Figure 3(B)** shows:

The alleles uniting to produce the genotype Yy (during fertilization)

Result:

- All F₁ generation plants have genotype Yy
- All have yellow seeds (since yellow is dominant)
- These heterozygous organisms are called hybrids

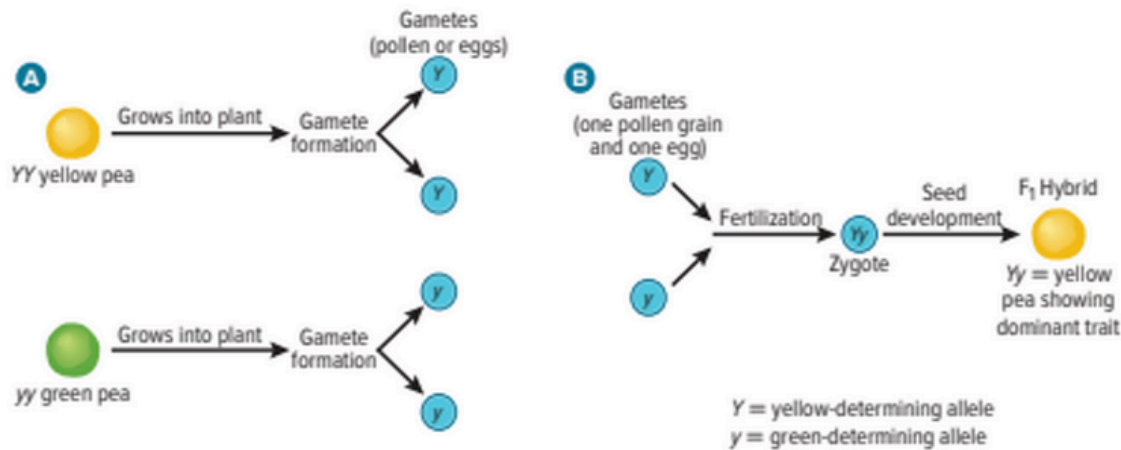


Figure 3

During gamete formation in the YY or yy plant, the two alleles separate, resulting in Y or y in the gametes. Gametes from each parent unite during fertilization.

Question:

Explain how the zygote that results from fertilization has a different genotype than either parent plant?

Each parent contributes only one allele (Y or y).

The zygote gets one allele from each parent, combining to form Yy — a new genotype that is different from either parent's genotype (YY or yy).

Law of Independent Assortment

Mendel also experimented with the shape of peas as well as the color.

He noticed:

- **Smooth, round** peas were expressed more often than **wrinkled** peas
- The **dominant** round peas had an allele R
- The **recessive** wrinkled peas had an allele r

Mendel crossed two types of peas in the parental generation:

- A **dominant** round, yellow pea (YYRR)
- A **recessive** wrinkled, green pea (yyrr)

He found that all of the F₁ generation had the same phenotype:

→ Round, yellow peas

→ Genotype: YyRr

Mendel allowed the F₁ plants (YyRr) to self-fertilize in a dihybrid cross.

He calculated the genotypic and phenotypic ratios in both F₁ and F₂ generations.

From these results, he developed the law of independent assortment, which states:

A random distribution of alleles occurs during gamete formation = **Law of Segregation**.

Genes on separate chromosomes sort independently during meiosis = **Law of**

Independent Assortment

(see Figure 4).



The random assortment of alleles results in four possible gametes:

→ **YR, Yr, yR, or yr**

Each of these is equally likely to occur.

When a plant self-fertilizes,

→ Any of the four male allele combinations can unite with

→ Any of the four female allele combinations

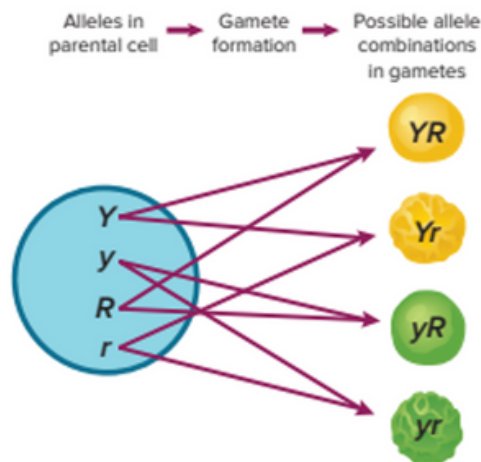


Figure 4

The law of independent assortment is demonstrated by the equal chance that each pair of alleles (Yy and Rr) can randomly combine with each other.

Predict:

How many possible gamete types can be produced?

Answer:

From a YyRr individual:

- You can produce 4 possible gamete types:
- YR, Yr, yR, yr

This follows the formula:

→ 2^n , where n = number of heterozygous gene pairs

→ So: $2^2 = 4$

Punnett Squares

In the early 1900s, **Dr. Reginald Punnett** developed what is known as a **Punnett square**.

It is used to **predict the possible offspring** of a cross between two known genotypes.

Punnett squares help keep track of the **possible genotypes** involved in a cross.



Monohybrid Cross

The diagram in **Figure 5** shows how Mendel continued his experiments by allowing the Yy plants to self-fertilize. A cross like this — involving hybrids for a single trait — is called a **monohybrid cross**.

The Yy plants produce two types of gametes (male and female):

- One with the Y allele
- One with the y allele

These gametes combine randomly, and this random fertilization results in four possible genotypes:

- YY, Yy, Yy, yy

(as shown in Figure 5)

*** The dominant Y allele is always written first — whether it came from the male or female gamete.**

In **Mendel's** F₁ cross, there are three possible genotypes:

1. YY
2. Yy
3. yy

• Genotypic ratio: **1 : 2 : 1**

• Phenotypic ratio: **3 : 1** (yellow : green)

Although YY and Yy are different genotypes, they produce the same phenotype (yellow).

Extension Example (Figure 6):

Do you have freckles like the boy in Figure 6?

The appearance of freckles is a dominant trait, represented by the letter F.

If both parents are heterozygous (Ff):

What phenotypes could you or your siblings have?

Freckles or no freckles

If both parents are Ff, you and your siblings have a 75% chance of having freckles and a 25% chance of having no freckles.

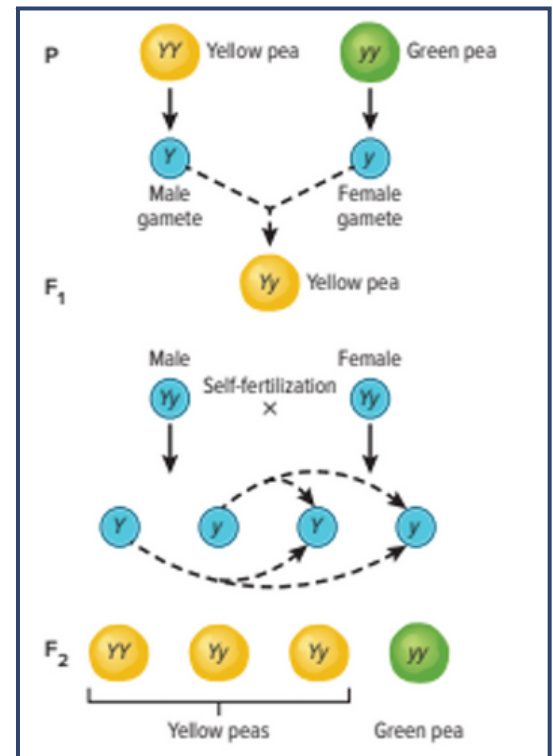


Figure 5

During the F₁ generation self-fertilization, the male gametes randomly fertilize the female gametes.



Figure 6

Freckles are a dominant trait.

Identify: the genotypes that can produce this phenotype.

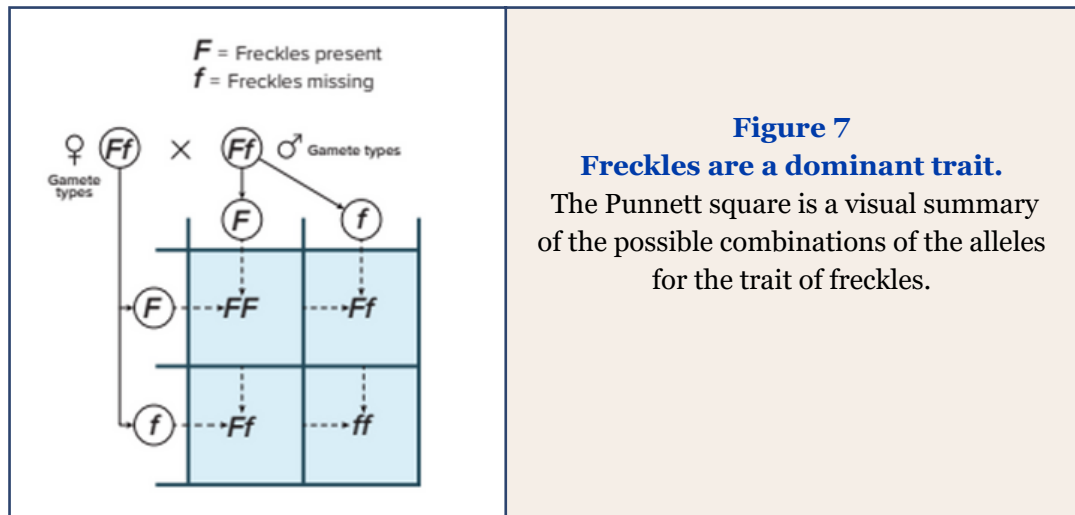
Answer:

Since freckles are dominant, the phenotype can be produced by:

- FF → Homozygous dominant
- Ff → Heterozygous

So the genotypes that can produce the freckled phenotype are:

→ FF and Ff



Examine the Punnett square in **Figure 7**.

The number of squares is determined by the number of different types of alleles—F or f—produced by each parent.

- In this case, the square is 2×2 because each parent produces two types of gametes
- Male gametes are written across the horizontal side
- Female gametes are written on the vertical side
- The combinations of male and female gametes are shown inside each square

Genotypes in the Punnett Square

- 1 square: FF
- 2 squares: Ff
- 1 square: ff

Genotypic ratio: **1 : 2 : 1**

Phenotypic ratio (**freckles to no freckles**): **3 : 1**

Dihybrid Cross

Once **Mendel** established how a single trait is inherited, he began to study two or more traits in the same plant.

In garden peas:

- Round seeds (R) are **dominant** to wrinkled seeds (r)
- Yellow seeds (Y) are **dominant** to green seeds (y)



If **Mendel** crossed:

- Homozygous yellow, round-seed plants (YYRR)

×

- Homozygous green, wrinkled-seed plants (yyrr)

→ The P cross would be YYRR × yyrr

→ The resulting **F₁ generation** genotype would be: **YyRr**

→ These are yellow, round-seed plants

These F₁ plants are called dihybrids because they are heterozygous for both traits.

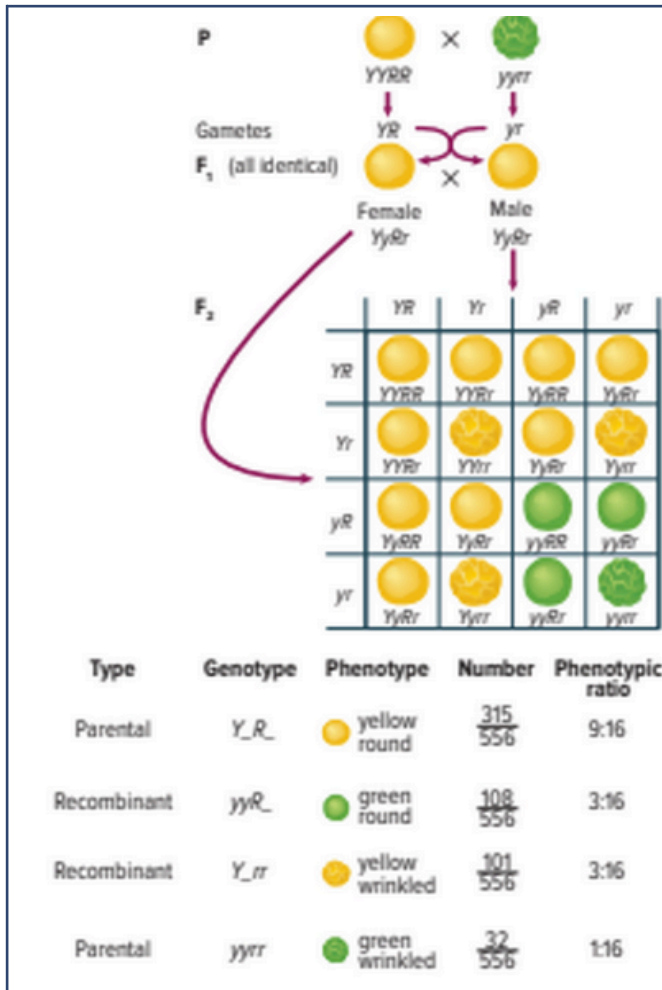


Figure 8

The **dihybrid Punnett** square visually presents the possible combinations of the possible alleles from each parent.

! Punnett Square - Figure 8

To examine this dihybrid cross, look at the Punnett square in **Figure 8**.

- The number of squares is based on the number of gamete combinations (from the alleles: YR, Yr, yR, yr)
- Each F₁ parent (YyRr) can produce 4 types of gametes

So the Punnett square is:

- 4 × 4 squares
- Each parent's 4 gametes are written **on the top and side**
- The combinations appear **inside the 16 squares**



Probability

The **inheritance of genes** can be compared to the **probability of flipping a coin**, as shown in **Figure 9**.

- The chance of a coin landing on heads is:

→ **1 out of 2, or $\frac{1}{2}$**

- If the coin is flipped twice, the probability of it landing on heads both times is:

→ $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$

Predicted vs. Actual Data

Actual data doesn't always perfectly match predictions.

- If you flip a coin twice, you might not get heads once and tails once
- You could get:

– Heads both times

– Tails both times

But:

The more times you flip the coin, the closer your results will be to the expected ratio of **1:1** (heads:tails)

Mendel's Experimental

- Mendel's results were not exactly **9:3:3:1**
- But as the number of offspring increased, his results got closer to the prediction

Conclusion:

The larger the number of individuals in a cross,

The more likely the outcome will match the predicted ratios from a Punnett square.



Figure 9

The probability of inheritance of genes can be modeled by flipping a coin.