Introduction to Genetics

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Mendel's laws of Inheritance

➢The principles of Mendelian inheritance were named by **Gregor Johann Mendel**

➢Experimented with pea plants (***Pisum sativum***)

Mendel's discoveries

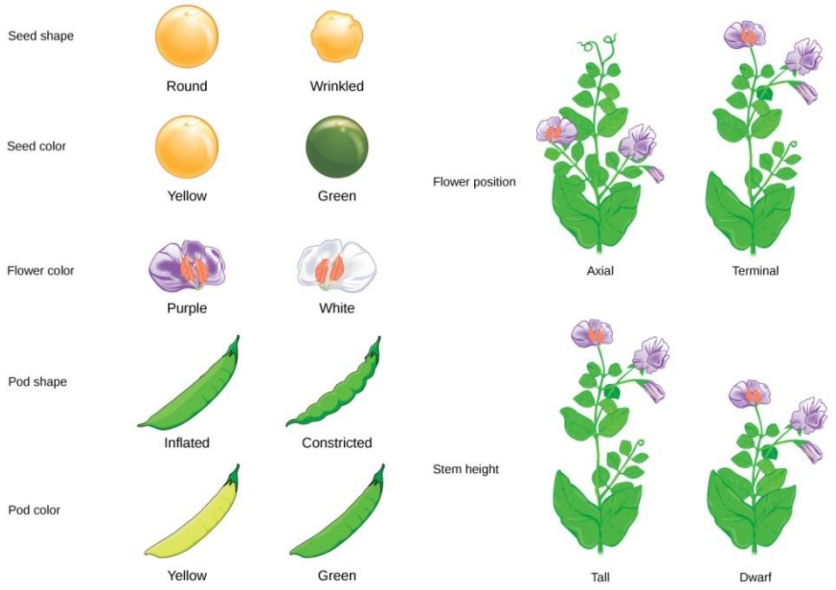
1. Characters are **unitary/discrete** e.g: purple vs. white, tall vs. dwarf.

2. Genetic characteristics have **alternate forms**, each inherited from one of two parents (alleles).

3. One allele is **dominant** over the other. The phenotype reflects the dominant allele. Gametes are created by **random segregation**.

4. Heterozygotic individuals produce gametes with an **equal frequency** of the two alleles.

5. Different traits have independent assortment.



Cited from: Concepts of Genetics by Pearson

Why was Pea Plant Selected for Mendel's Experiments?

1. The pea plant can be **easily grown** and maintained.

2. They are naturally **self-pollinating** but can also be **cross-pollinated**.

3. It is an annual plant, therefore, **many generations** can be studied within a short period of time.

4. It has several **contrasting characters.**

➢He conceived the idea of **heredity units**, which he called hereditary "**factors**".

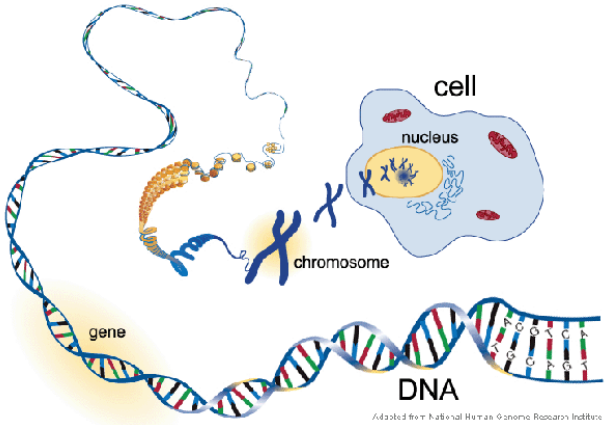
➢Mendel found that there are alternative forms of factors—now called **genes**—that account for variations in inherited characteristics.

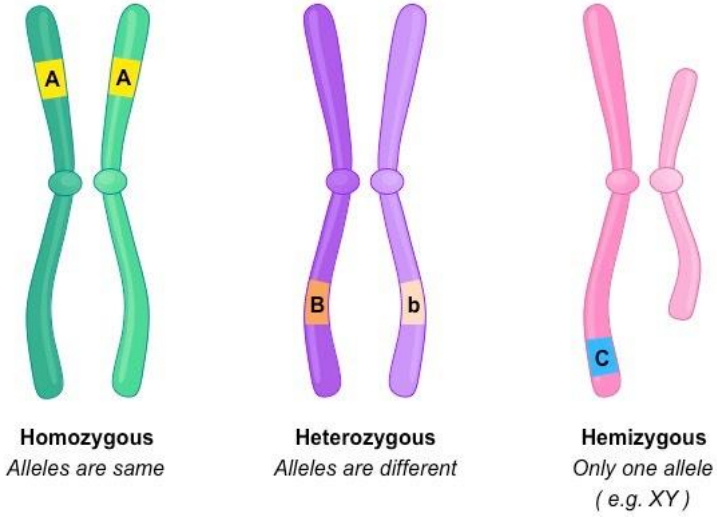
➢For example, the gene for flower color in pea plants exists in two forms, one for purple and the other for white. The alternative "forms" are now called **alleles.**

➢For each trait, an organism inherits two alleles, one from each parent. These alleles may be the same or different.

➢An organism that has two identical alleles for a gene is said to be **homozygous** for that gene (and is called a **homozygote**).

➢An organism that has two different alleles for a gene is said be **heterozygous** for that gene (and is called a **heterozygote**).





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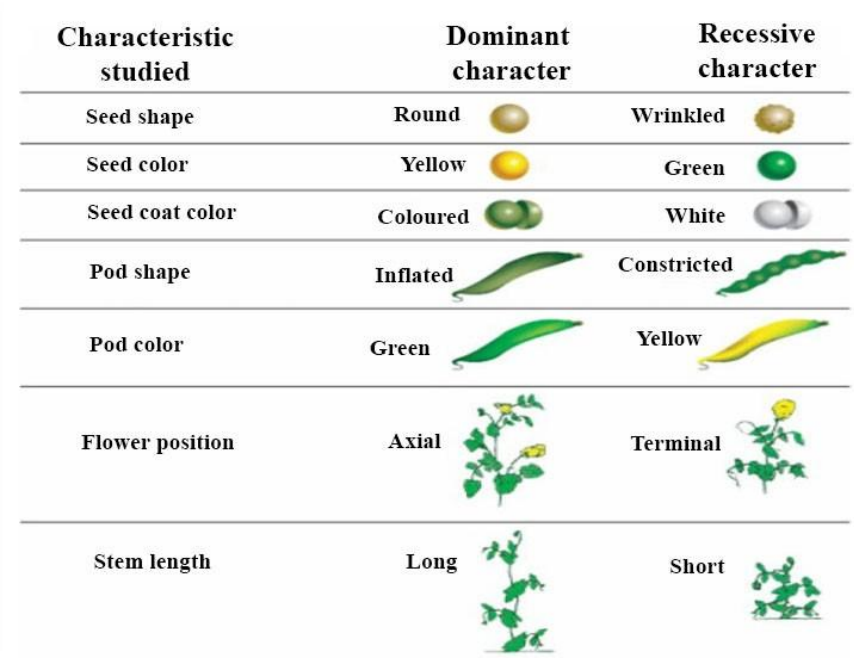
Mendel selected the following characters of pea plants:

- Seed shape (round or wrinkled)
- Seed color (green or yellow)
- Seed coat color (green/coloured or white)
- Pod shape (constricted or inflated)
- Pod color (green or yellow)
- Position of flowers (axial or terminal)
- Plant stem length (tall/long or dwarf/short)



Characteristic studied	Dominant character	Recessive character
Seed shape	Round	Wrinkled
Seed color	Yellow	Green
Seed coat color	Coloured	White
Pod shape	Inflated	Constricted
Pod color	Green	Yellow
Flower position	Axial	Terminal
Stem length	Long	Short

Characteristics Mendel used in his experiments

Cited from: Concepts of Genetics by Pearson

Mendel’s laws

Mendel’s laws also known as laws of inheritance :

- **Law of Dominance**
- **Law of Independent Assortment**
- **Law of Segregation**

Law of Dominance

According to the law of dominance, hybrid offsprings will only inherit the dominant trait in the phenotype. The alleles that are suppressed are called as the **recessive** traits while the alleles that determine the trait are known as the **dormant** traits.

Law of Independent Assortment

The law of independent assortment states that, a pair of trait **segregates independently** of another pair during gamete formation. As the individual heredity factors assort independently, different traits get equal opportunity to occur together.

Law of Segregation

The law of segregation states that during the production of gametes, two copies of each hereditary factor **segregate,** so that offspring **acquire one factor** from each parent. In other words, allele (alternative form of the gene) pairs segregate during the formation of gamete and re-unite randomly during fertilization.

Law of Dominance

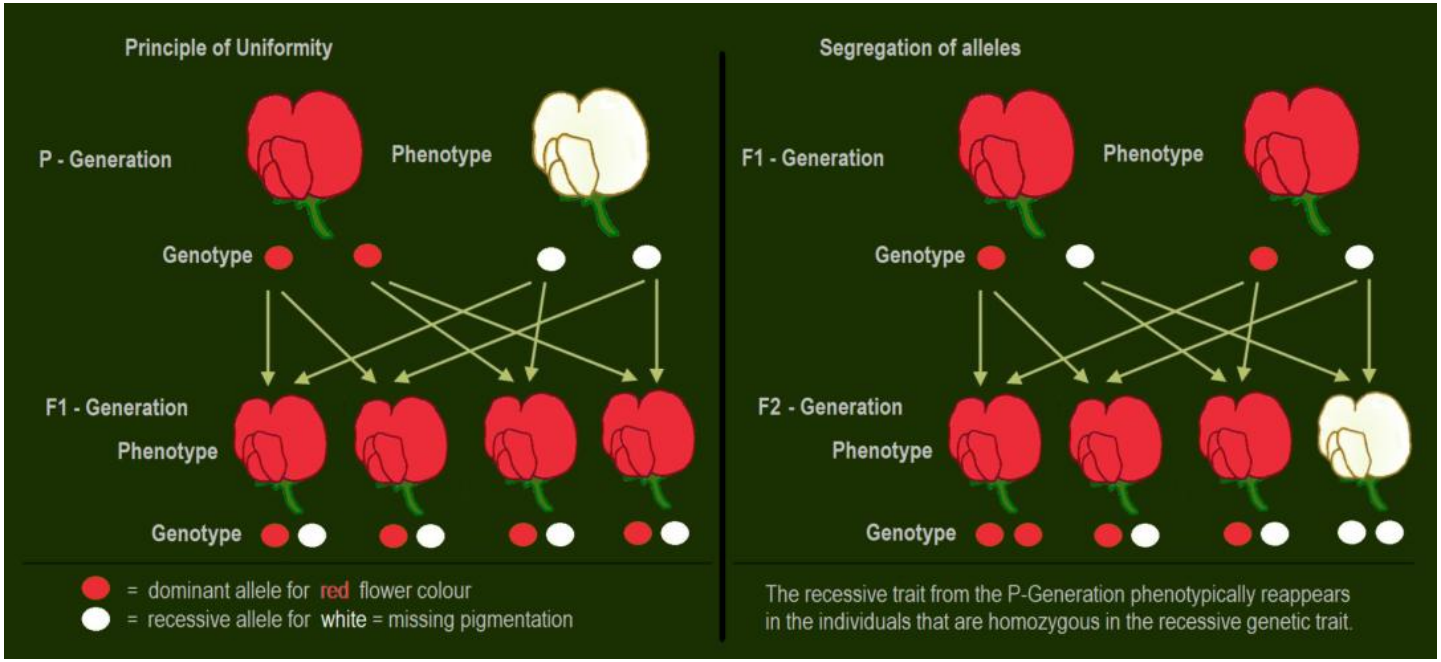
➢The principle of dominant states that in a heterozygote the **dominant allele** will cause the recessive allele to be **"masked":** that is, not expressed in the phenotype.

➢When he crossed pure bred **white flower and red flower** pea plants by artificial pollination, the resulting flower colour was not a blend in F-1 generation.

➢Rather than being a mix of the two, the offspring in the first generation (F1-generation) were **all red-flowered**. Therefore, he called this biological trait ***dominant.***

➢Only if an individual is homozygous with respect to the recessive allele then only recessive trait will be expressed. Therefore, a cross between a homozygous dominant and a homozygous recessive organism yields a heterozygous organism whose phenotype **displays only the dominant trait.**

➢The F1 offspring of Mendel's pea crosses always looked like one of the two parental varieties. In this situation of **"complete dominance**," the dominant allele had the same phenotypic effect whether present in one or two copies.



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P-Generation and F1-Generation: The dominant allele for red flower hides the phenotypic effect of the recessive allele for white flowers.

F2-Generation: The recessive trait from the P-Generation phenotypically reappears in the individuals that are homozygous with the recessive genetic trait.

➢When he allowed self-fertilization in the uniform looking F1-generation, he obtained both colours in the F2 generation with a **red flower to white flower ratio of 3 : 1**

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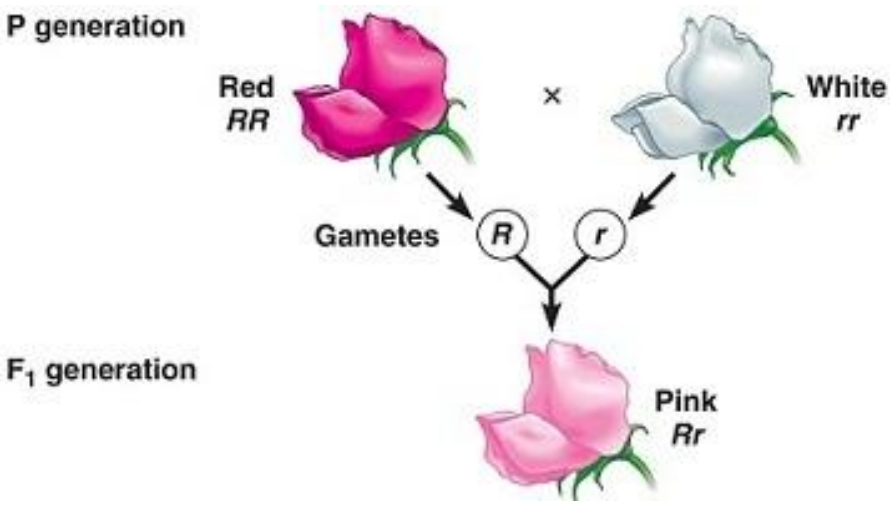
- For some characteristics, the F1 hybrids have an appearance in between the phenotypes of the two parental varieties. A cross between two *Mirabilis jalapa* plants shows an exception to Mendel's principle, called incomplete dominance.

- Flowers of heterozygous plants have a phenotype somewhere between the two homozygous genotypes.

- In cases of intermediate inheritance (incomplete dominance) in the F1-generation Mendel's principle of uniformity in genotype and phenotype applies as well.



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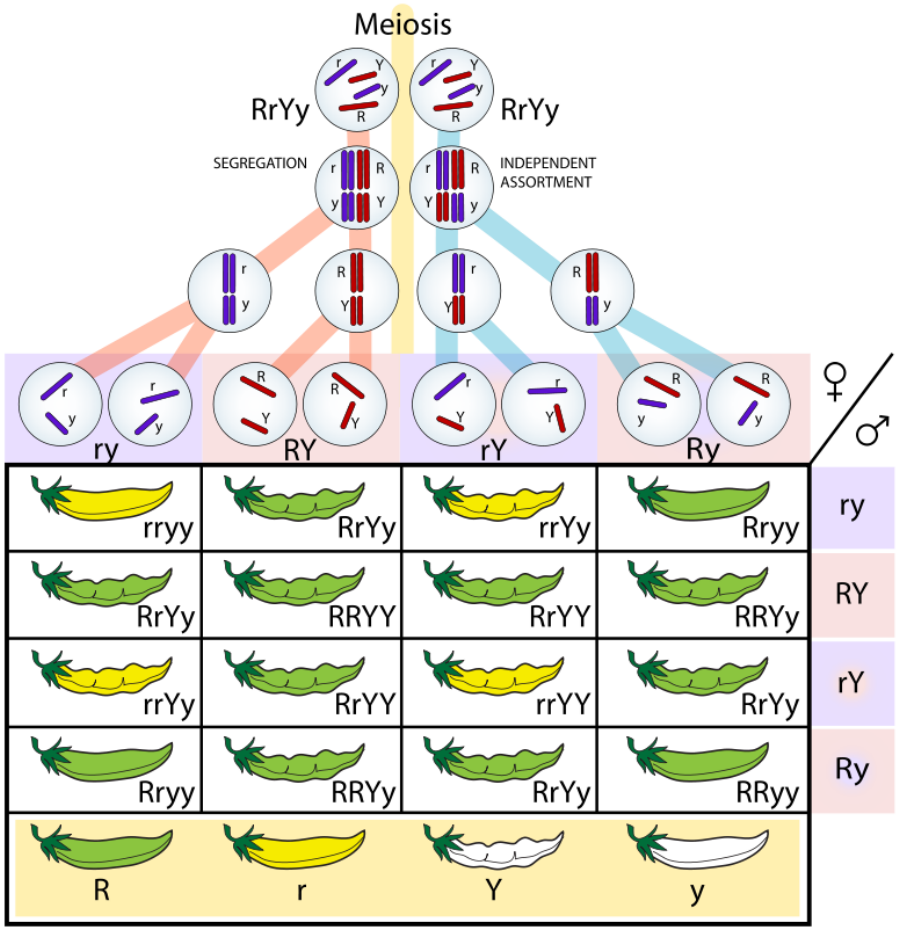
Law of Independent Assortment

- The Law of Independent Assortment states that alleles for separate traits are passed independently of one another.
- The biological selection of an allele for one trait has nothing to do with the selection of an allele for any other trait.
- Mendel found In his monohybrid crosses, a 3:1 ratio between dominant and recessive phenotypes
- In dihybrid crosses, however, he found a 9:3:3:1 ratio.
- This shows that each of the two alleles is inherited independently from the other, with a 3:1 phenotypic ratio for each.



Segregation and independent assortment are consistent with the chromosome theory of inheritance

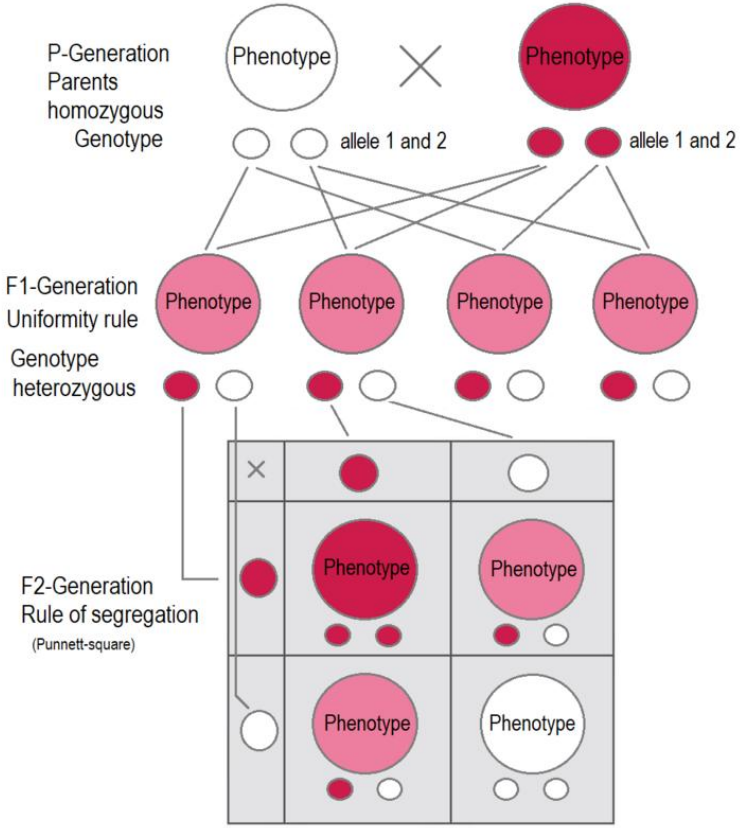
Cited from: Concepts of Genetics by Pearson

Law of Segregation of genes

➢The Law of Segregation of genes applies when two individuals, both heterozygous for a certain trait are crossed, for example hybrids of the F1-generation.

➢The offspring in the F2-generation differ in genotype and phenotype, so that the characteristics of the grandparents (P-generation) regularly occur again.

➢ In a dominant-recessive inheritance an average of 25% are homozygous with the dominant trait, 50% are heterozygous showing the dominant trait in the phenotype (genetic carriers), 25% are homozygous with the recessive trait and therefore express the recessive trait in the phenotype. The genotypic ratio is 1 : 2 : 1, the phenotypic ratio is 3 : 1.



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Mirabilis jalapa and *Antirrhinum majus* are examples for intermediate inheritance.

F1-generation: Heterozygous plants have "light pink" flowers—a mix of "red" and "white".

F2-generation: Shows a 1:2:1 ratio of red : light pink : white

Chromosomal Theory of Heredity

Walter Sutton **Theodor Boveri**

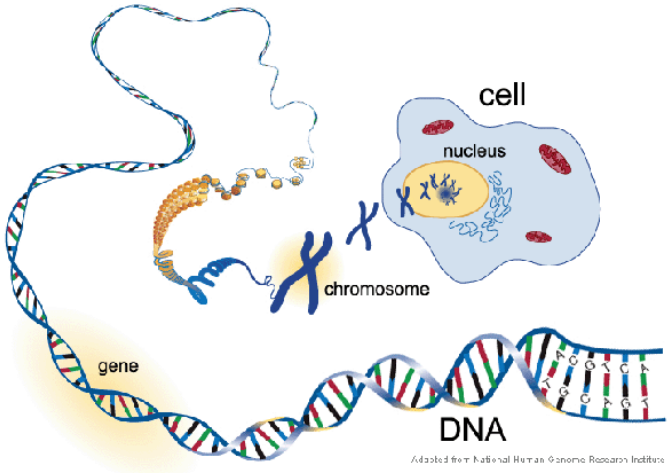
➢Long before chromosomes were visualized under a microscope, the father of genetics, Gregor Mendel, began studying heredity in **1843.**

➢ With the improvement of **microscopic techniques** during the late 1800s, cell biologists **could stain** and visualize **sub-cellular structures** with dyes and observe their actions during **cell division and meiosis**.

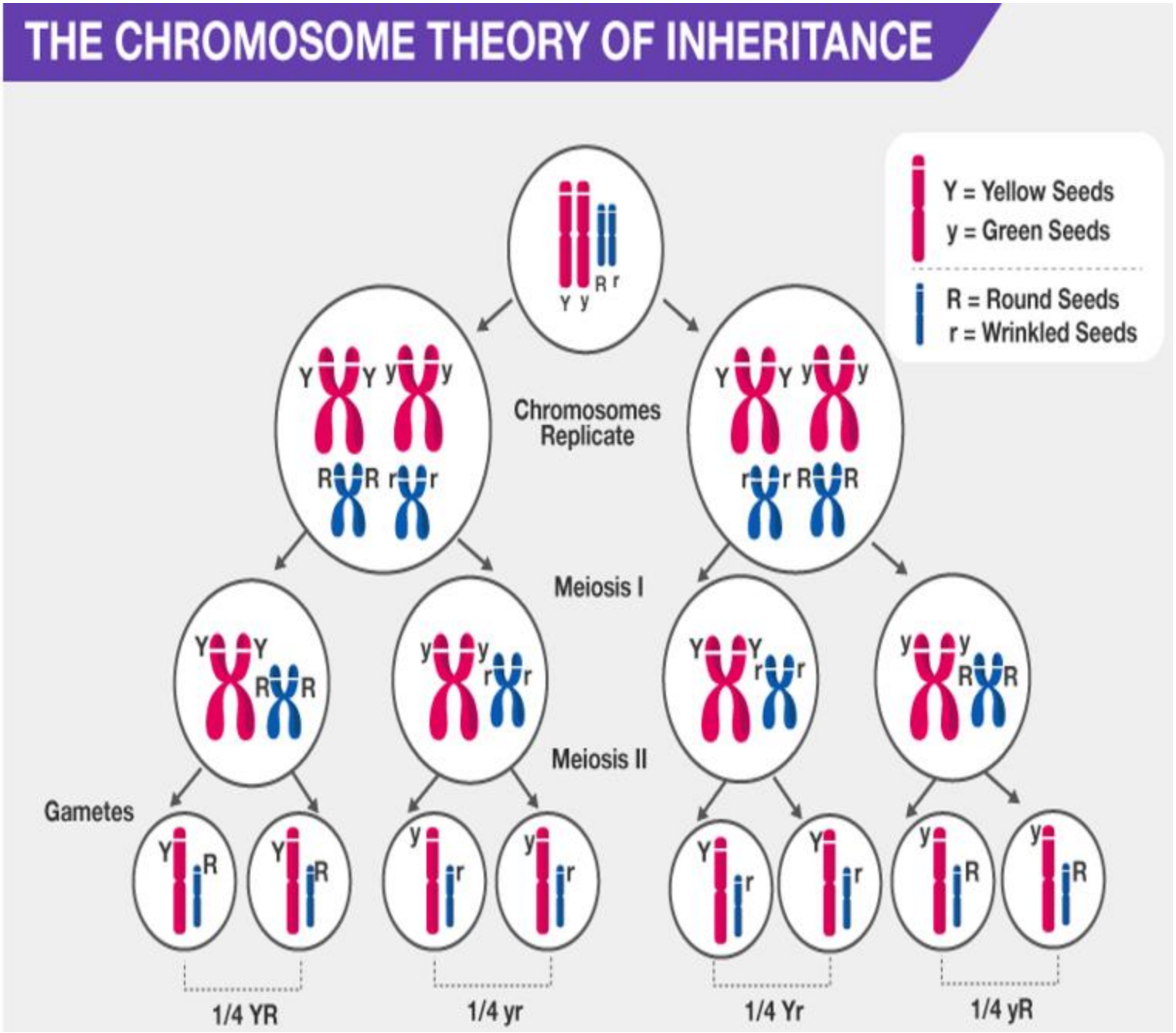
➢The chromosomal theory of inheritance was given by Boveri and Sutton in the early 1900s, also known as the **chromosome theory of inheritance** or the **Sutton–Boveri theory**

➢It states that chromosomes are seen in all dividing cells and pass from one generation to the next, are the basis for all **genetic inheritance.**

➢According to this theory, **genes are the units of heredity** and are found in the chromosomes.



THE CHROMOSOME THEORY OF INHERITANCE



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