HEREDITY AND EVOLUTION

KEY CONCEPT

Reproduction brings about some differences in the offspring. These differences are not easily seen because of similarities of offspring with their parents but there are variations that do exist due to unequal distribution of chromosomes during cell division in sexual reproduction in animals. Organisms that sexually reproduce cause maximum successful variations as compared to asexually reproducing organisms. Humans reproduce sexually and hence certain heredity traits are passed on to us which has resulted in such dynamic changes over the years. Acquiring characteristics or traits from one generation to the other is nothing but inheritance.

Gregor Mendel, also known as the Father of Genetics, conducted immense research and studies on this inheritance of traits. He researched on plant breeding and hybridization and conducted his experiments on pea plants to show the inheritance of traits in living organisms. In this chapter, we shall study the mechanisms which give rise to variations and the long-term consequences of the accumulation of variations .

KEY WORDS

Chromosomes are long thread-like structures present in the nucleus of a cell which contain hereditary information of the cell in the form of genes.

DNA is a chemical in the chromosome which carries the traits in a coded form.

Gene : A gene is the basic physical and functional unit of heredity. Genes are made up of DNA. Some genes act as instructions to make molecules called proteins.

Trait : An inherited character like features ,which is normally inherited and has its detectable variant too. Tall and dwarf are traits of a character i,e height.

Allele : One of two or more possible forms of a gene that are found at the same place on a chromosome.

Hybrid : An individual having two different alleles for the same trait.

Dominant Traits : The traits that express themselves in an organism in every possible combination and can be seen are called Dominant traits.

Recessive Traits : A trait which is not expressed in the presence of a dominant allele is known as recessive.

Phenotype : The expression of the genotype ,which is an observable and or which can be measured.

Genotype : The genetic constitution of an individual organism.

Monohybrid Cross : When only one character is considered while crossing two organisms, then such a cross is known as monohybrid cross. The cross between two monohybrid traits (TT and tt) is called a Monohybrid Cross. Monohybrid cross is responsible for the inheritance of one gene.

Dihybrid Cross : A cross in which inheritance of two pairs of contrasting is studied. E.g., If a plant with round and green pea is crossed with a plant with wrinkled and yellow pea,

Progeny : An offspring as a daughter organism.

Gametes : Gametes are an organism's reproductive cells. They are also referred to as sex cells. Female gametes are called ova or egg cells, and male gametes are called sperm.

Homozygous : Homozygous is a genetic condition where an individual inherits the same alleles for a particular gene from both parents.

Heterozygous : Heterozygous refers to having inherited different forms of a particular gene from each parent. A heterozygous genotype stands in contrast to a homozygous genotype, where an individual inherits identical forms of a particular gene from each parent.

Heredity: The passing on of characteristics (as the color of the eyes or hair) from parents to offspring.

Genetics : Study of heredity is termed as Genetics.

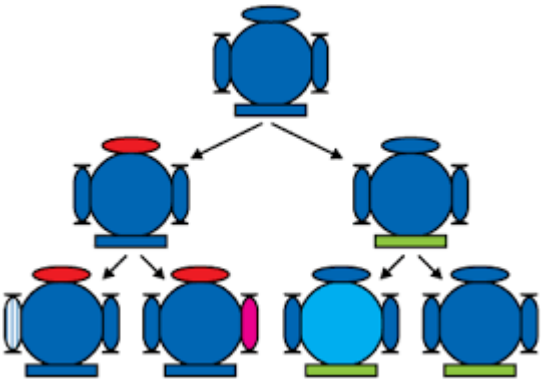
CONTENT

- **Accumulation of Variation During Reproduction:**

- Reproduction is a process that gives rise to new offspring that are similar to the parents but with some variations between them due to the process of DNA copying.
- It may be noted that these differences are slightly visible in asexual reproduction as in plants, but there are greater variations and diversity in the case of sexual reproduction which involves the fusion of two different gametes.
- This leads to the variations that are seen in each generation.
- These variations may be advantageous or disadvantageous to the individuals and may or may not enable them to cope with the changing environmental conditions. For example, the bacteria that can tolerate higher temperatures would survive the heat waves.
- These variations accumulate over generations in the evolutionary process owing to the environmental factors and lead to the formation of new species and are equally important for their survival**.**

For Example: The given figure represents the situation of a single bacterium reproducing to produce two resulting bacteria. The resultant two bacteria divide again and the four individual bacteria generated would be very similar. There would be only very minor differences between

them, generated due to small inaccuracies in DNA copying. However if sexual reproduction is involved, even greater diversity will be generated.



- **Heredity**

- The biological process that maintains or passes on the characteristics and traits of the parents to their offspring is termed heredity. Example, colour of skin or hair, eyes, height etc.
- This is responsible for maintaining the variations in generations and thus the evolution of species over a period of time.

- **Inherited Traits**

- The characteristics that are inherited from the parents are termed as traits, like eye colour or skin colour in humans. If the parent has brown and black eyes, then the offspring may inherit a brown or black or a combination of both.
- This depends on the set of genes responsible for that trait.
- The traits that are inherited in this manner are termed inherited traits and these are the cause of the variations in the population, though everyone has a similar basic feature.Laws should be made to impose a total ban on the poaching (killing) or capturing of any animal or bird belonging to an endangered species.

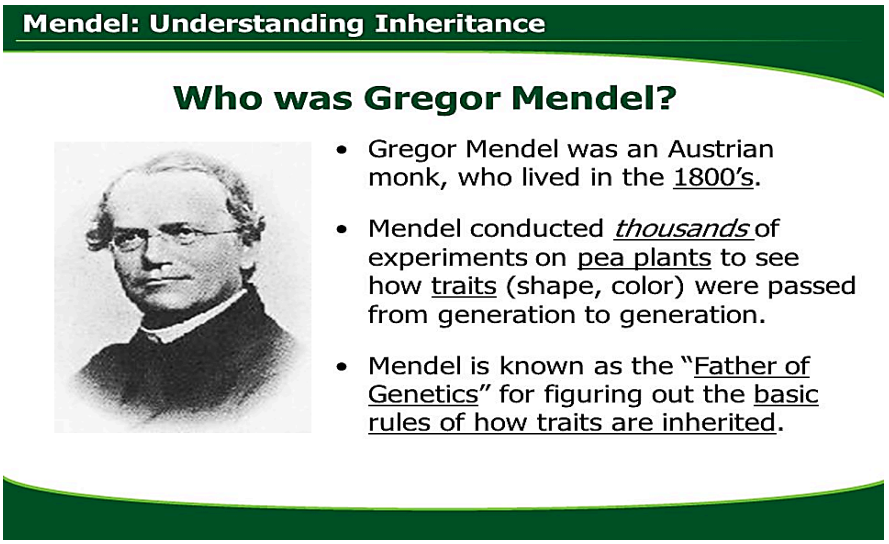
- **Acquired Characters**

- The traits that are acquired by an organism over the period of its lifetime are termed as acquired characters.
- These characters may or may not get transferred to the next generation.
- Examples are cycling, swimming etc.

- **Rules for the Inheritance of Traits- Mendel's Contributions**

The rules of inheritance come from the fact that both the parents contribute equally to the development of the traits in the offspring.
Gregor Johann Mendel, often referred to as the 'Father of genetics' was a pioneer who used his science and mathematics knowledge to frame these laws of inheritance. He did so using pea plants for his experiments as he found them easy to grow and they had a greater number of

visible characteristics like tall/short, white/violet flowers, round/wrinkled seeds. Mendel found during his experiments that there were some factors controlling the traits, which are now known as genes.



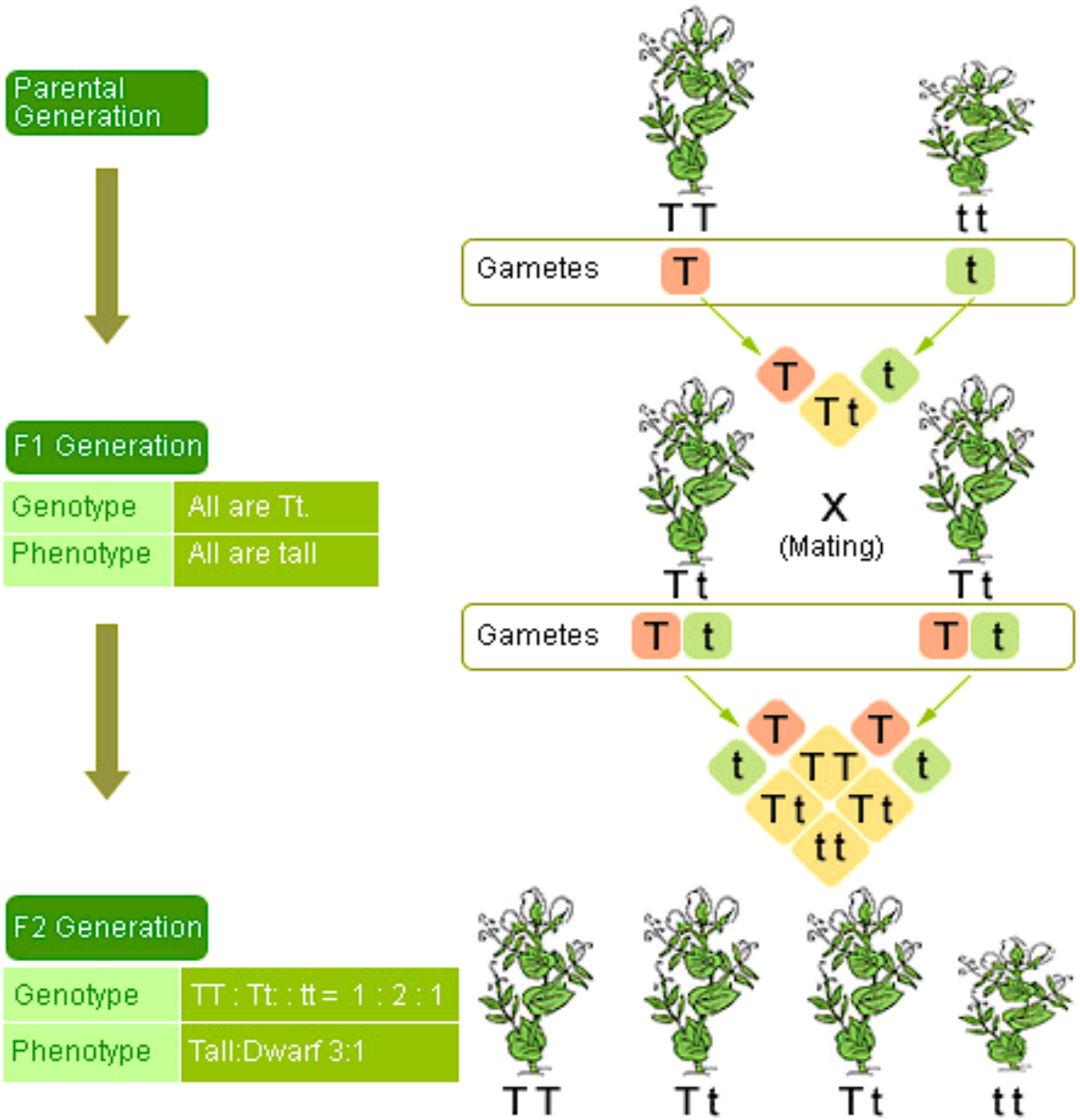
- The genes are present as a pair for a specific trait and then they are termed alleles.
- Depending on the genes the expression of the traits could be either dominant or recessive. If we take the tallness in a plant as a dominant trait, then it can be denoted by 'T' and shortness in the plant would be a recessive trait, denoted by 't'. Thus the plant will be tall if its alleles are 'TT' or 'Tt'. The condition is when the alleles of the genes have the same allele for a trait, they are termed as homozygous. Example - TT or tt. The condition when the alleles of the genes have the different alleles for a trait, they are termed as heterozygous. Example - Tt.
- The morphological expression of a single character is termed as phenotype. Example - tallness or shortness, round or wrinkled seeds of the plant.
- The genetic constitution or the allele pair for a specific trait is termed as the genotype. Example - Tt or t tot TT.
- Mendel was a mathematician so, he found the statistics of the traits in each generation by using a statistical method known as Punnett square for predicting the possible genotypes and phenotypes of the offspring.

o **Mendel's Experiment**

- Mendel started his experiment on the pea plants. He conducted first monohybrid and then dihybrid crosses.
- Monohybrid Cross: The cross in which Mendel showed inheritance of dominant and recessive characters is monohybrid cross. To observe inheritance of single pair of contrasting characters.
- He took pure tall (genotype TT) and pure dwarf (genotype tt) pea plants and cross pollinated them to obtain first generation or first filial generation. In this figuration (F1 generation) he obtained only tall plants. This meant that only one of the parental traits was seen, not the mixture of the two. The plants of F generation or progeny are then self-pollinated to obtain F2 generation

or progeny. Now all plants were not tall. He obtained 75% tall plants and 25% dwarf plants i.e. the phenotypic ratio was 3:1. This indicates that in the F1, generation both tall and dwarf traits were inherited but tallness expressed it self. Tallness is a dominant trait and dwarfness is a recessive trait. F2 generation has a genotypic ratio of 1 : 2 : 1 of three types of plants represented by TT, Tt and tt as shown in the cross.

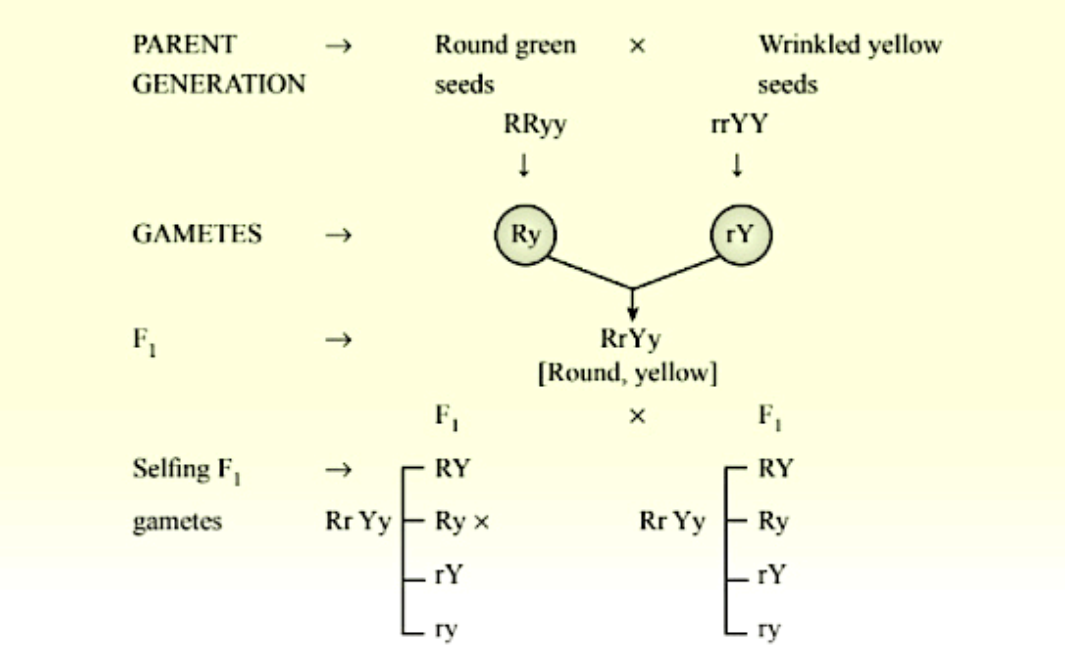
- Phenotypic ratio—Tall : Dwarf 3 : 1
  Genotype ratio—Pure Tall : Hybrid Tall : Pure Dwarf 1 : 2 : 1



- Mendel also carried out experiments to observe inheritance of two pairs of contrasting characters, which is called dihybrid cross.

- Dihybrid Cross - An example of a dihybrid cross is the cross between a homozygous pea plant with round yellow seeds and wrinkled green seeds. The round yellow seeds are represented by RRYY alleles, whereas the wrinkled green seeds are represented by rryy. The gametes formed from these alleles are RY and ry.

    - Round and yellow seeds-9.
    - Round and green seeds-3.
    - Wrinkled and yellow seeds-3.
    - Wrinkled and green seeds-1.



F_1 gametes →

	RY	Ry	rY	ry
RY	RRYY	RRYy	RryY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

o Conclusions from Mendel's Experiments

- The genetic makeup of the plant is known as the genotype. On the contrary, the physical appearance of the plant is known as phenotype
- The genes are transferred from parents to the offspring in pairs known as allele.
- During gamete formation when the chromosomes are halved, there is a 50% chance of one of the two alleles to fuse with the other parent.

- When the alleles are the same, they are known as homozygous alleles and when the alleles are different they are known as heterozygous alleles.

- **MENDEL 3 LAWS OF INHERITANCE -** The two experiments lead to the formulation of Mendel's laws known as laws of inheritance which are:

  1. Law of Dominance
  2. Law of Segregation
  3. Law of Independent Assortment

1. Law of Dominance

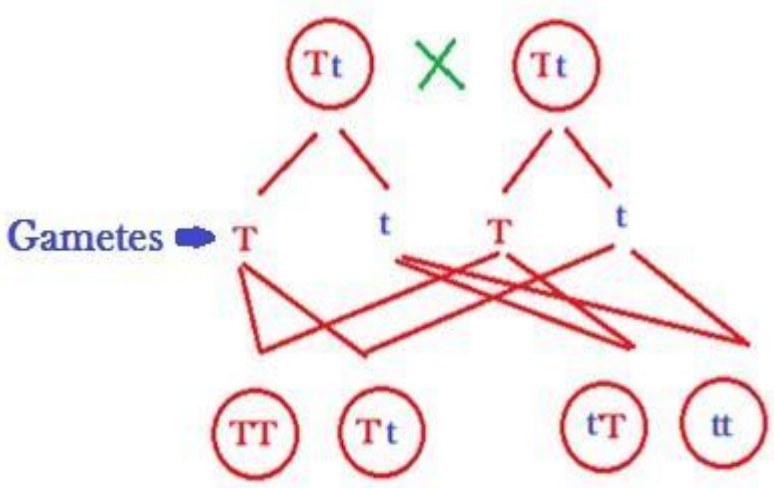
It is also called Mendel's first law of inheritance. According to the law of dominance, hybrid offspring will only inherit the dominant trait in the phenotype. The alleles that are suppressed are called as the recessive traits while the alleles that determine the trait are known as the dominant traits. E.g. In Tt (heterozygous tall plant), T is dominant and t is recessive.

Tt

Heterozygous Tall

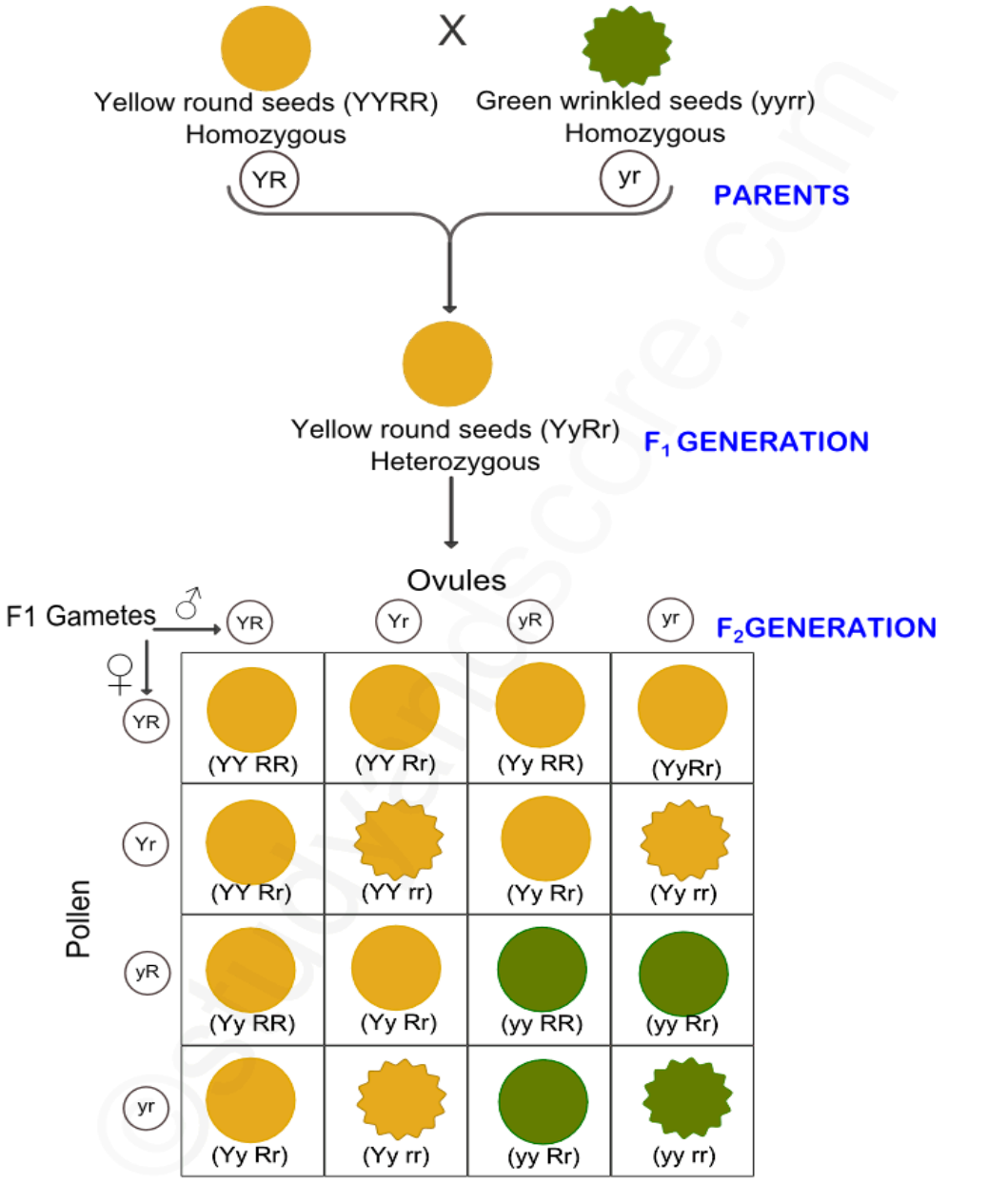
2. Law of Segregation

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. Example: In a hybrid tall plant Tt, 'T' & 't' segregate only during gamete formation.



3. Law of Independent Assortment

During gamete formation, segregation of alleles of one pair is independent of the segregation of alleles of the other pair. E.g. Self-pollination of hybrid plants with Round & Yellow seeds. In this experiment, Mendel took 2 contrasting characters- colour of seed and shape of seed of the pea plant. It was observed that colour & shape of the seeds were independent of each other. Though we started with Round-Yellow & Green-Wrinkled combinations, we obtained even Round-Green and Yellow-Wrinkled combinations in F2 generation. This shows that the alleles R,r and Y,y segregated independently.



Dihybrid cross beween Yellow round & Green Wrinkled seed Pea plant

Reason for the selection of pea plants for the genetic experiments

The reason for the selection of pea plants for the genetic experiments are

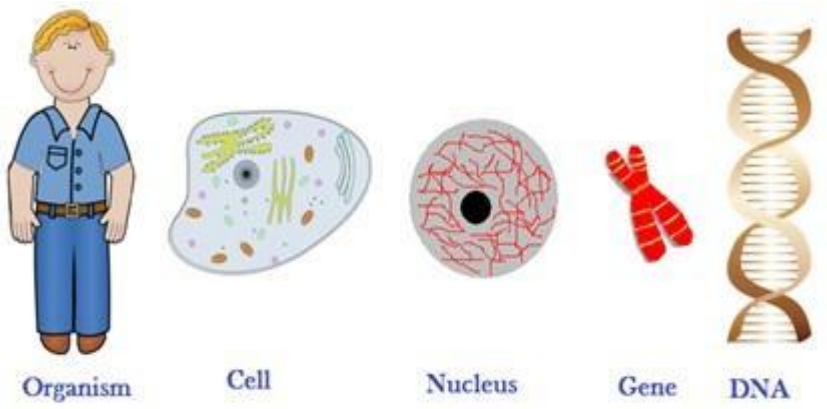
- Easy to grow in the garden.
- The flowers of pea plants are hermaphrodite, i.e. flowers have bisexual characteristics.
- Easy to obtain pure breed plant through self-fertilization
- The generation time of pea plants is less.
- They have excellent disease resistance and have an optimal rate of survival.

Mendel selected seven pairs of contrasting characters of pea plants for his experiments which are as follows:

	Height	Seed Shape	Seed Color	Seed Coat Color	Pod Shape	Pod Color	Flower Position
Dominant	 Tall	 Round	 Yellow	 Green	 Inflated (full)	 Green	 Axial
Recessive Trait	 Short	 Wrinkled	 Green	 White	 Constricted (flat)	 Yellow	 Terminal

How do these Traits get expressed?

Genes control the traits of living organisms.

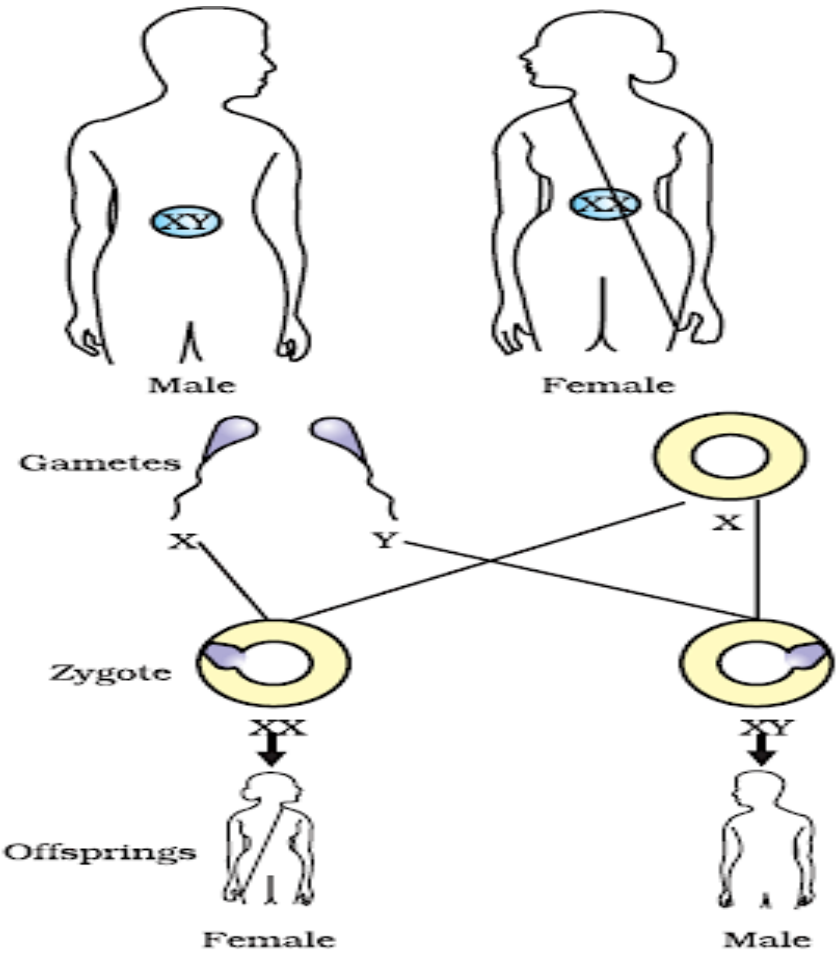


Let's take the example of Mendel's 1st Experiment with Tall & dwarf plants. Height of the plant depends on the growth hormone, Auxin. We know that if this Auxin hormone is more, height is more. The hormone is secreted by respective glands, which in turn is controlled by the proteins. Gene has the information for synthesis of proteins. If a gene has alteration, enzyme can be less or more efficient which in turn can make the height less or more.

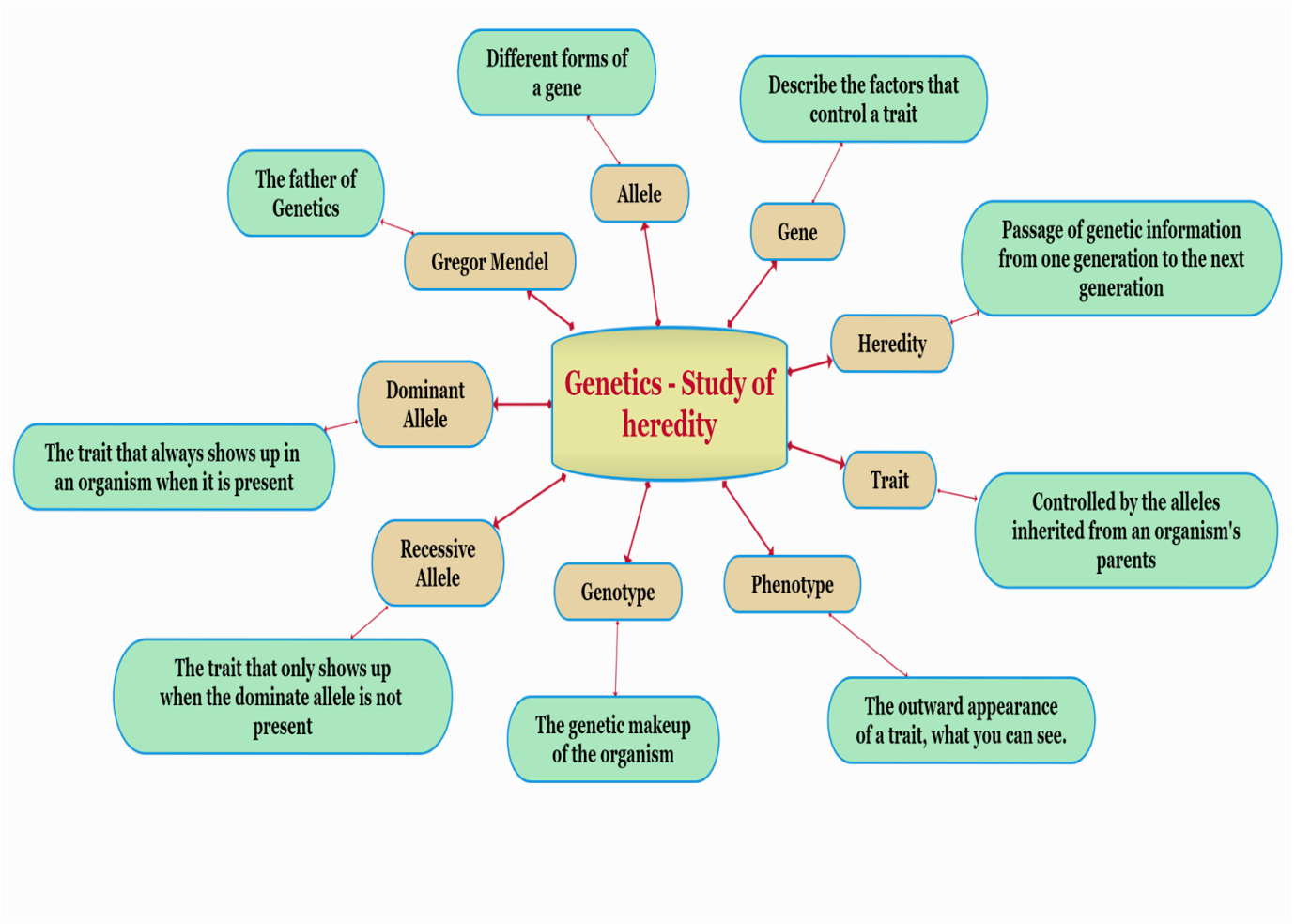
During sexual reproduction both the parents contribute equally to the DNA of next generation. They actually contribute a copy of the same gene for example; when tall plant is crossed with short plant the gametes will have single gene either for tallness or for shortness. F1 generation will get one gene for tallness and other for shortness also.

Sex determination - The process of determining the sex of an individual, based on the composition of the genetic material is called sex determination**.**

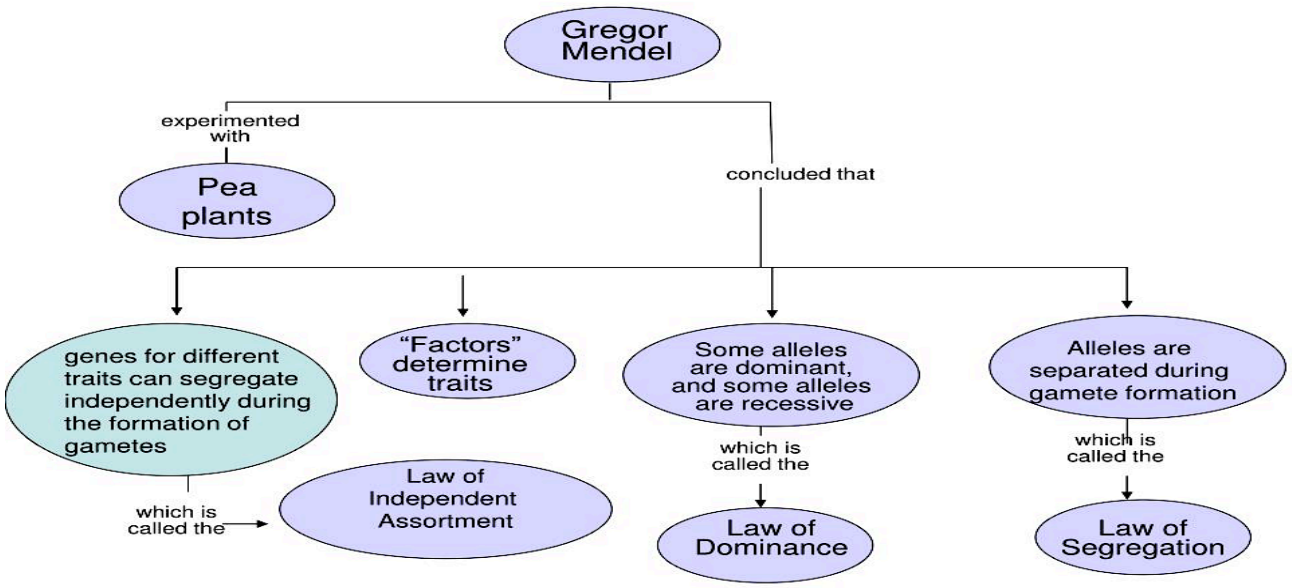
- Humans have 23 Pairs of Chromosome
- Out of 23 Pairs One Pair is Called Sex Chromosome
- Women have a perfect pair of sex chromosomes, and is XX
- Men have an imperfect pair of sex chromosomes, and is XY
- During reproduction all children will inherit an X chromosome from their mother
- From father, it may receive either X or Y chromosome
- A child who inherits an X chromosome from her father will be a girl, and one who inherits a Y chromosome from him will be a boy.



FLOW CHART


Genetics - Study of heredity
Different forms of a gene
Allele
Describe the factors that control a trait
Gene
The father of Genetics
Gregor Mendel
Passage of genetic information from one generation to the next generation
Heredity
Dominant Allele
The trait that always shows up in an organism when it is present
Trait
Controlled by the alleles inherited from an organism's parents
Recessive Allele
The trait that only shows up when the dominate allele is not present
Genotype
The genetic makeup of the organism
Phenotype
The outward appearance of a trait, what you can see.

Concept Map


Gregor Mendel
experimented with
Pea plants
concluded that
genes for different traits can segregate independently during the formation of gametes
which is called the
Law of Independent Assortment
"Factors" determine traits
Some alleles are dominant, and some alleles are recessive
which is called the
Law of Dominance
Alleles are separated during gamete formation
which is called the
Law of Segregation