Heredity

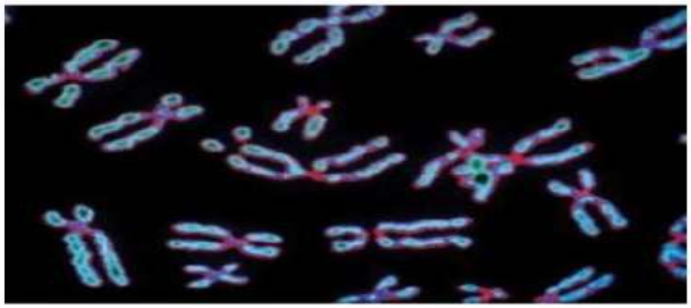
Heredity or Hereditary is the process of passing the traits and characteristics from parents to offsprings. The offspring cells get their features and characteristics aka genetic information from their mother and father. Heredity and genetics are the reason you look so much like your parents. Genetics is a branch of science that studies the genes, genetic variation, and heredity in living organisms. Let us learn all about it.

What is Heredity?

In the simplest of words, heredity refers to the passing of traits or characteristics through genes from one generation (parent) to the other generation (offspring). This heredity is very evidently seen in sexual reproduction, as the variation of characteristics that are inherited is high.

During the sexual reproduction process, variation occurs due to some error in DNA copying. Variation is important because it contributes to evolution and forms the basis of heredity. Variation is caused due to positive gene mutations, the interaction of genes with the environment and various combinations of genetic material. Remember that

variation can occur through asexual reproduction process too. But these variations are not very noticeable.



(Source – Encyclopedia Britannica)

Gregor Mendel- The Father of Genetics

Acquiring characteristics or traits from one generation to the other is nothing but inheritance. Here, both the parents contribute equally to the inheritance of traits. It was Gregor Mendel, known as the Father of Genetics, who conducted immense research and studied this inheritance of traits.

It was with his research on plant breeding and hybridization that he came up with the laws of inheritance in living organisms. He conducted his experiments on pea plants to show the inheritance of traits in living organisms.

He observed the pattern of inheritance from one generation to the other in these plants. And thus he came up with Mendel's Laws of Inheritance, which can be summarized under the following headings:

- Law of Dominance
- Law of Segregation
- Principle of Independent Assortment

Know Some Terms

- *Gene* – It is the basic unit of inheritance. It consists of a sequence of DNA, which is the genetic material. A point to be noted here is that genes can mutate and can take two or more alternative forms.
- *Alleles* – The alternative forms of genes which arise as a result of mutation. They are found in the same place on the chromosome and effect the same characteristic or trait but in alternative forms.
- *Chromosomes* – These are thread-like structures of nucleic acids and protein that are found in the nucleus of most living cells. They carry the hereditary or genetic information in the form of genes.

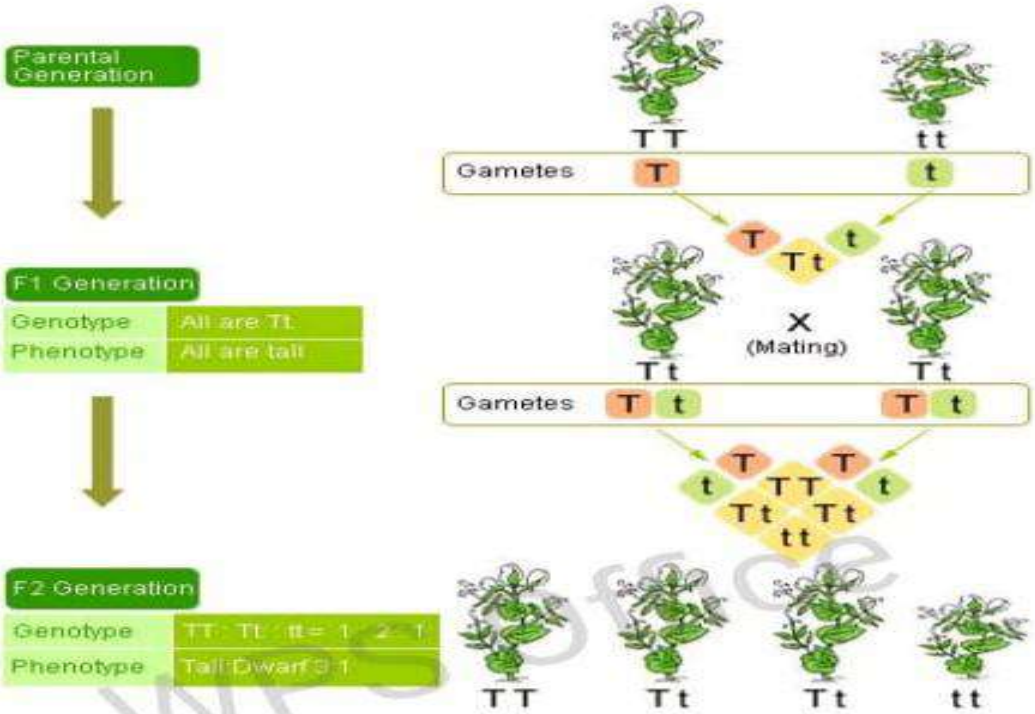
- *Genotype* – It is the complete heritable genetic identity of an organism. It is the actual set of alleles that are carried by the organism. This includes even the alleles that are not expressed, which means even the alleles that do not influence a specific trait that they code for.
- *Phenotype* – It is the description of the actual physical characteristics of an organism, the way the genotype is expressed.
- *Dominant alleles* – When an allele affects the phenotype of an organism, then it is a dominant allele. It is denoted by a capital letter. For example, "T" to express tallness.
- *Recessive alleles* – An allele that affects the genotype in the absence of the dominant allele s called a recessive allele. It will express itself in the small letter. For example – "t" for tallness.
- *Homozygous* – Each organism has two alleles for every gene. (Each chromosome has one each) If both the alleles are same then it is called homozygous. If tallness is the trait, then it is expressed as "TT"

- *Heterozygous* – If the two alleles are different from each other, then they are heterozygous in nature. If tallness is the trait, then it is expressed as "Tt".

Mendel's Experiments

Monohybrid Cross

It is the cross between two pea plants which have one pair of contrasting characters. For Example, a cross between a tall pea plant and a short (dwarf) plant. The following diagram explains this in detail.



(Source – Pinterest)

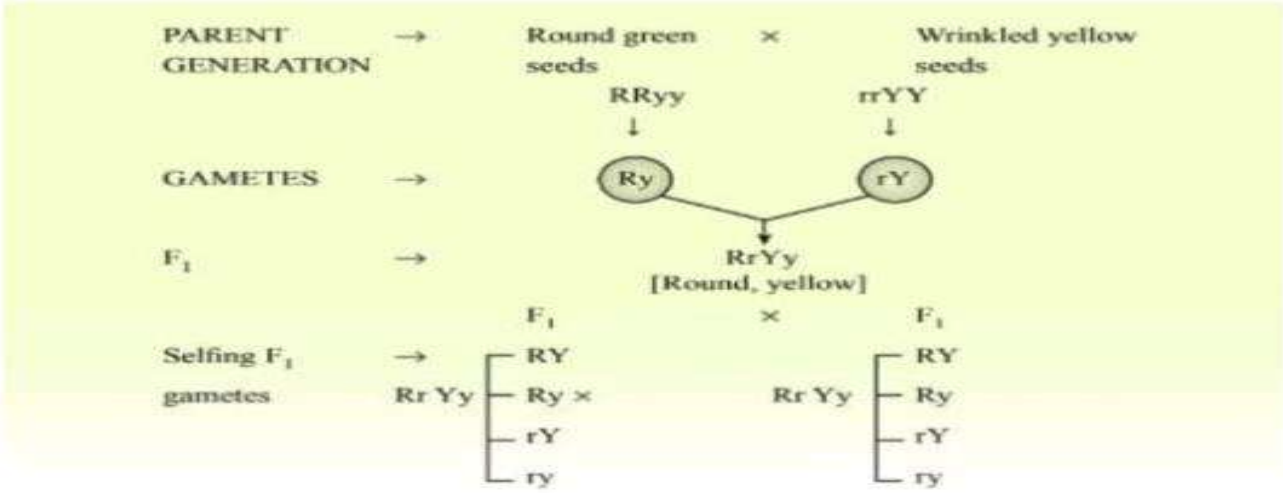
Observations & Conclusion

- In the first generation (F1), the progeny were tall. There was no medium height plant.
- In the second generation (F2), 1/4th of the offspring were short and 3/4 were tall.
- The Phenotypic ratio in F2 is 3: 1 (3 tall: 1 short)
- The Genotypic ratio in F2 – 1: 2: 1 – (TT: Tt: tt)

- For a plant to be tall, a single copy of "T" is enough. But if a plant has to be short, both the copies should be "t"
- Characters like 'T' are the dominant traits as they are expressed and 't' are recessive traits as they remain suppressed.

Dihybrid Cross

It is the cross between two plants which have two pairs of contrasting characters. This takes into consideration alternative traits of two different characters. For example, a cross between one pea plant with round and green seeds and the other pea plant having wrinkled and yellow seeds. The following diagram explains the dihybrid cross in detail.



F1 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

Observations & Conclusion

- The F1 generation is 100% hybrid. When RRyy crosses with rrYY, all were Rr Yy with round and yellow seeds in the first generation. The Round and Yellow seeds are the dominant characters.

- In F2, the phenotype ratio is 9:3:3:1. The genotype ratio is a very complex one.
- This shows that the genes are inherited independently of each other.

Solved Questions For You

Q: Name which Mendel's experiments that show that traits are inherited independently?

Ans: The Dihybrid cross experiment that Mendel performed with the pea plants, shows that traits are inherited independently. In a cross between two plants with two pairs of contrasting characters, the expression of traits occurs independently.

Evolution

We have heard this particular statement that we have evolved from our ancestors. What is seen now on planet earth is a result of evolution. So, what exactly is evolution? Is there any science behind it? Come let us find out interesting facts about evolution and speciation.

The Basic Idea of Evolution

There is a lot of science behind the theory of evolution. Scientists and researchers have done intensive studies to show how living things evolved and how traits and characteristics passed on from generations to generations.

Ultimately, when we speak of evolution, we actually speak of the genetic characteristics that are inherited and passed on from one generation to the other. The whole process of evolution gives rise to biodiversity at all levels, including species, organisms, and even molecules.

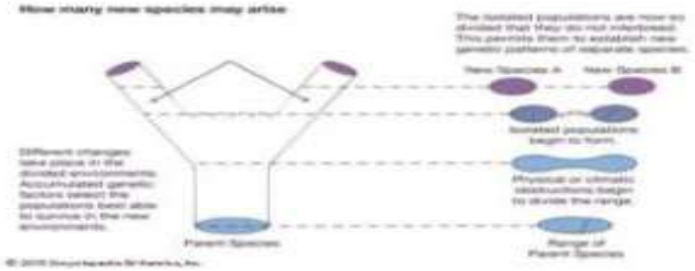
An important basis on which the theory of evolution is based on is that all species are related and gradually change over time. But the frequency of an inherited trait that undergoes a change is spread over generations. Genes control the traits. Therefore we can say that the frequency of genes in a population changes over generations.

Acquired and Inherited Traits

Acquired traits are qualities that are developed in an individual in response to certain conditions in the environment. These cannot be transferred to the progeny. They only help an organism to survive. And therefore, they do not direct the evolution process. Examples include bending of plants due to wind, calluses (Corns or even hard skin) on fingers etc.

Inherited traits are the characters or qualities that are passed on from parents to their offspring i.e. from one generation to the other generation. They have a major role in the evolution process. Some examples include the color hair, eyes, shape of the nose, bone structure etc.

Speciation



(Source – Encyclopedia Britannica)

The formation of new species from the existing species is called as speciation. Here, a single evolutionary lineage splits up into two or more genetically independent lineages. The occurrence of speciation is due to the following reasons:

- Genetic drift – A random change in the frequency of alleles over successive generations in a population.
- Gene flow – This speciation occurs between populations which are partly separated but not completely separated.
- Natural selection – Nature selects and consolidates those organisms which are more suitable and adaptable. They also possess favourable variations.
- Geographical isolation – This is caused by mountains, rivers, and other geographic features. This form of isolation leads to reproductive isolation. As a result, there is no flow of genes in the separated groups of the population.

Evolution and Classification

So, how does evolution play a role in classifying organisms? In your previous classes, you have learned how living organisms are classified into various groups and subgroups. The basis of classification is the

closeness of the species in each group. Each subgroup of species has a recent common ancestor which again has a distant common ancestor. And, so as you go backward, you will then trace back to the very beginning of life on earth, where all organisms have evolved from a common ancestor. Thus you can see how classification and evolution are interlinked.

Species are classified based on their evolutionary relationships. When species have common characteristics, they are closely related. The more closely they are related, the more likely is the chance of a common ancestor. Similarities between organisms thus allow us to classify them together.

Tracing Evolutionary Changes

Homologous Structures vs. Analogous Structures

(Source: DifferenceBetween.com)

When we trace the changes that have evolved over a period of time, we notice that there is a common ancestor. When we trace these evolutionary changes, we can conclude the evidence of evolution through the following:

Homologous evidence – The homologous organs seen in organisms show us they have a common ancestor. For example, when you look at the forelimbs of whales, humans, birds, and dogs, the bone structure is similar, but they look different on the outside.

Analogous evidence – Some physical features in organisms may look alike. But these have no common ancestor. These traits have evolved independently. The basic structure of the organs is different, but they perform similar functions.

Fossils (Paleontological evidence) – These are the preserved remains of organisms that lived in the past. These fossils also help us trace back the evolution process.

Stages of Evolution

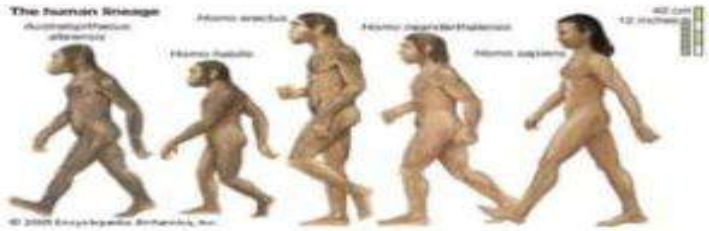
When you see the evidence of evolution, you can come to a conclusion that the stages of evolution have occurred bit by bit, over

many generations. An example could be the emergence of feathers, which may have started as a means to provide insulation in cold weather. Slowly, this must have improvised to help in the ability to fly.

The artificial selection also has a role to play in the evolutionary stages. Humans have successfully used this concept, in developing certain varieties of food crops and vegetables, to suit their needs. For example, the different varieties of broccoli, cauliflower, red cabbage, kale etc. have been developed through the artificial selection process. The common ancestor here is the wild cabbage!

Human Evolution

When we speak about evolution, I am sure, as science students, you all would love to know about human evolution. Even the evolution of humans has been traced using the same evidence such as the fossils, DNA sequencing, time dating, excavating etc. According to established theories, all human beings evolved in the continent of Africa. And therefore all humans are a single species, *Homo sapiens*.



(Source – Encyclopedia Britannica)

Solved Question For You

Q: Differentiate between homologous organs and analogous organs with examples.

Ans. Homologous organs are the organs that have a same structural design but different function. Eg. The forelimbs of whales, humans, birds, and dogs have the same bone structure. But each performs functions according to the habitat that the animals live in.

Analogous organs are the organs that perform similar functions but have the basic structural design is different. Eg. The wings of a bat and a fly are analogous organs.

Sex-Linked Inheritance

How is it that parents and the offspring look similar? The progeny shares some traits or characteristics that are inherited from the parents, and this passes on again to the next generation. In a broader perspective, everything is related to genes, genetics, and heredity. In humans, this concept can be understood clearly through sex-linked inheritance.

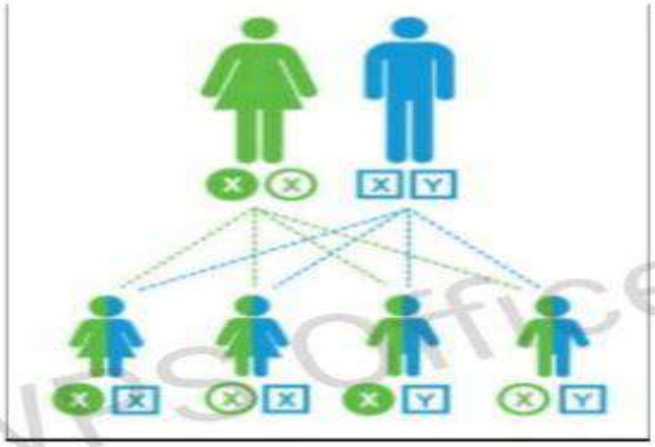
What is Sex-Linked Inheritance?

How does one determine whether an unborn baby is a male or a female? Did you know that the genes and the chromosomes play an important role in this determination? The sex of the individual is largely genetically determined.

A human being has 23 pairs of chromosomes. The 22 pairs of chromosomes are called autosomes and are the non-sex chromosomes. One pair of chromosomes is called the sex chromosomes. Every human individual, both male and female, has two sex chromosomes. Depending on the type of sex chromosomes present, the gender is determined. Females have XX, i.e. two X chromosomes while males have XY, i.e. one X chromosome and one Y chromosome.

Genes that are carried by the sex chromosomes are said to be sex-linked. They carry the genes that determine whether an individual is a male or female, along with other traits.

Sex Determination



Sex-Determination-(Source -Science of biogenetics)

Males have XY chromosome and Females have XX chromosomes. When a baby inherits the X chromosome from the father and the X chromosome from the mother, then the baby will be a female baby. When a baby inherits the Y chromosome from the father and the X chromosome from the mother, then the baby will be a male baby.

When you see the chromosomes, notice that it is the Y chromosome that determines the sex-linked inheritance of the baby. A mother i.e. a female has both XX chromosomes, whereas the father (male) has XY chromosomes. The Y chromosome of the male has a gene called SRY ("sex-determining region of Y").

It is this gene that determines that a developing embryo will be a male. An embryo having XX chromosomes does not have SRY gene and hence develop into a female, while the embryo with XY chromosomes has the SRY gene and develops into a male.

Human Blood Groups and Their Inheritance

Did you know that your blood group is determined by the blood group of your parents? The inheritance of the blood groups is controlled by specific genes. In humans, there are different types of blood groups. The standard recognized form of classifying blood groups is the ABO blood grouping, given by Karl Landsteiner. According to this, there are four main blood groups, which are A, B, O and AB groups.

The following figure explains how blood groups are inherited from parents.

Mother's Blood Type	Father's Blood Type: A	B	AB	O	Child's Blood Type
A	A or O	A,B,AB or O	A,B,or AB	A or O	
B	A,B,AB or O	B or O	A,B,or AB	B or O	
AB	A,B,or AB	A,B,or AB	A,B,or AB	A or B	
O	A or O	B or O	A or B	O	

Determination Of Blood Groups(Source – Wikihow)

Solved Questions for You

Q.1: Explain why the father determines the sex-linked inheritance of the child?

Ans. The father (male) has XY chromosomes. The Y chromosome of the father has the SRY gene. ("Sex-determining region of Y"). This gene determines if an embryo will be a male or a female. An embryo having XX chromosomes does not have SRY gene and hence develop into a female, while the embryo with XY chromosomes has the SRY gene and develops into a male.