4. Heredity and evolution

At the end of this Chapter, you will be competent to...

- Investigate how characters are inherited.
- Investigate how genetics is important to mankind.
- Investigate the factors and the process of natural selection in relation to evolution.

4.1 Diversity among organisms

You already know that there is a large number of plants and animals in the biosphere. Each species of organism can easily be identified from the other due to the specific characteristic features possessed by them.

Did you ever think why each species differs from the other, as well as how each species continues to possess the same characteristics down generations?

Fig. 4.1 members of smilar age

Although all members of the human species possess similar characteristics, every person has physical features different from the other. Even among identical twins certain differences can be seen. Fig. 4.1 and Fig 4.2. will clarify this further. This is valid for other species of animals as well. If we consider a particular plant species, all plants in that species will not be the same. This can be seen in Fig. 4.4 where different varieties of tomato species produce different types of fruits.

Fig. 4.2 identical twins

Fig. 4.3 different butterfly species

Fig. 4.4 different types of tomatoes

Diversity in the human species

Fig. 4.5 diversity of the colour of the hair

In order to study the diversity among members of the same species it is convenient to study the variations among different persons. People can be fair, dark or brown in skin colour. Their hair may be black, brown or blonde. Hair may be straight or curly. (Fig. 4.6) Ear lobes may be attached or free. (Fig. 4.7). In addition to the above external features, people show diversity in functions of the different organs too. Are you right -handed? There are left handed people too. See whether you can roll your tongue as shown in the Fig. 4.8. May be you cannot. When you fold the fingers of your two hands together as shown in Fig. 4.9, thumb of which hand is on top? With some, it is the right hand while with some, it is the left hand.

Fig. 4.6 hair may be straight or curly

Fig. 4.5 Ear lobes may be attached or free

Fig. 4.8 the ability to roll the tongue

All of the above features are those that have come down generations. They have come not only from your parents but also from previous generations.

Fig. 4.9 the position of the thoumb when you fold the fingers

Diversity among members of the family

You may be similar to your parents in many features. You may also be different to them in certain other ways. The following activity will clarify this.

Activity 4.1

Observe the features and abilities among the members of your maternal and paternal relations and make a list.

Identify the features and the abilities that have been acquired from previous generations.

Identify those features possessed by you or your silbings which were no seen in the members of the previous generations.

According to your observations, it may be clear to you that certain features of your maternal relations and certain features of your paternal relations have been passed down from generation to generation. Such features or characters that are passed down from generation to generation are called genetic characters. You may also notice that any of your siblings may have a character not seen in any of the relations involved in the activity. Yet, if you probe further up your ancestral line, they may have possessed that feature. This shows that genetic characters may even skip a generation and appear in the next generation.

In summary, we can say,

- Inheritance of genetic characters is common to all organisms.
- The passing down of genetic characters is called **heredity.**
- The process of passing down genetic characters is called **inheritance.**
- In the field of scientific studies, inheritance is called **genetics.**

In Activity 1, a number of genetic characters seen among the members of a family were identified and listed. Compare your list with the following:

Inherited characters
- Brown / tan skin colour
- Black hair
- Curly hair
- Free ear lobes
- Black eyes
- Right-handedness
- Inability to roll the tongue
- When hands are folded, the right thumb is on top.

Let us identify some hereditary features that are rarely met. You may have even seen some persons with these features.

1. Syndactyly - Two adjacent fingers are bound together to some distance by a fold of skin.
2. Polydactyly - Possession of 6 fingers or toes. (Fig. 4.10)
3. Albinism - Possession of a very white skin, blonde hair, and white eye lashes (Fig.4.11).
4. Black, brown or blue eyes - (Fig 4.12).

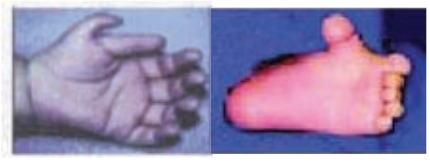


Fig. 4.10 Polydactyly

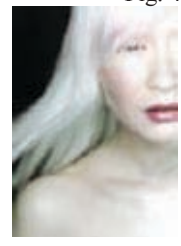


Fig. 4.11 Albinism

Fig. 4.12 Black or blue eyes

Non-inherited characters

Characters that are dependant on climatic differences, environmental conditions such as nutrition, exercise or activities are not inherited characters. Fig 4.13 shows some such features.

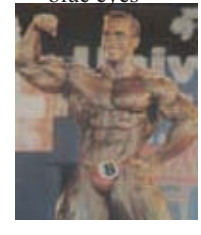


Fig. 4.13 developing muscles by exercise

How are characters inherited from generation to generation?

When we breed new plants by vegetative reproductive methods, we can assume that characters are passed down through the part of plant used for vegetative reproduction. Yet, how does this happen when higher plants and anmals reproduce by sexual methods?

The person who did the first investigations on this phenomenon was an Austrian Catholic priest, Gregor Mendel. The findings of scientists before him were of use to him in his work.

Mendel's experiments on heredity

For the experiments on heredity in the year 1865, the plant he selected was the garden pea plant *(Pisum sativum)*. The reasons for selecting this particular plant for his work were:

- It could be grown easily.
- The short life period.
- Pure bred plants were easily obtained. 'Pure bred' means that selected characters were preserved in generation after generation without change.
- Plants differed in easily identifiable contrasting characters (e.g. Yellow seeds / green seeds, round seeds / wrinkled seeds, tall plants /short plants etc.)
- Naturally self pollinated but could be cross pollinated, if necessary. Fertile offspring could be bred which could carry on the generation.

Mendel selected seven such contrasting characters. He examined only one couple of character at a time. The procedure he followed with respect to tall plants and short plants are as follows.

He selected a sample of pure bred tall plants and pure bred short plants. He took pollen from the tall plants and placed them on the stigma of the short plants, and at the same time, he took pollen from the short plants and placed them on the stigma of the tall plants.

The seeds from this cross pollination produced offspring which were all tall. They were called the F_1 generation or First filial generation.

What do you think about the short character in this cross? Did it disappear? According to Mendel the tall character became **dominant** while the short character became **recessive**.

Next, Mendel allowed the F_1 tall offspring to get self pollinated.

The second generation produced tall and short plants in the proportion of 3:1,Tall: Short.This second generation was called the F_2 generation or Second filial generation.

The short character that was recessive in the F_1 generation reappeared in the F_2 generation. This was an important observation. Since Mendel considered only one set of contrasting characters at one time, this was called a Monohybrid inheritance.

The pattern in which characters are inherited in a monohybrid cross

Given below are the results of a series of experiments conducted by Mendel for 7 characters of the Pea plant. *(pisum sativum)*

Character	Hybrid	F1 Generation	F2 Generation		Approx. Ratio
			Dominant	Recessive	
Colour of flower	Purple x White	Purple	Purple 705	White 224	3:1
Colour of seed	Yellow x Green	Yellow	Yellow 6022	Green 2001	3:1
Shape of seed	Round x Wrinkled	Round	Round 5474	Wrinkled 1850	3:1
Colour of pod	Green x Yellow	Green	Green 428	Yellow 152	3:1
Shape of pod	Inflated x Constricted	Inflated	Inflated 882	Constricted 299	3:1
Position of flower	Terminal x Axial	Axial	Axial 652	Terminal 207	3:1
Height of plant	Tall x Short	Tall	Tall 787	Short 277	3:1

Table 4.1 results of Mendel's experiments

- In the F_1 generation, the tall character was dominant in all the plants.
- In the F_2 generation, tall plants and short plants were produced in the ratio 3:1.

The above results show that all these characters were inherited in the same pattern. Plants of both F_1 and F_2 generation had only one of the characters of the parent plants. There were no plants with intermedite characters. Mendel concluded that the reason for this is that there were two factors to determine each contrasting character in the pea plant.

In genetics, certain symbols are used to represent these factors. The **dominal** factor is denoted in capital letters while **the recessive** factor is indicated in simple letters.

Accordingly, capital T denotes the tall character and t denotes the recessive character. Every hereditary character has a pair of factors. Hence we can denote the factors in the plants as follows:

Pure bred tall plant, TT

Pure bred short plant, tt

Tall plant with short character become recessive, Tt

Using these symbols we can write down the way in which characters are inherited in a monohybrid cross of a tall plant and a short plant in the garden pea plants.

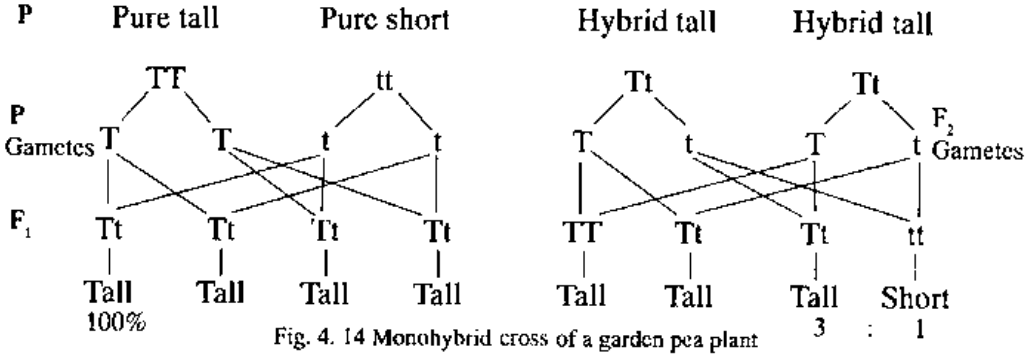


Fig. 4. 14 Monohybrid cross of a garden pea plant

Assignment 1

Select another contrasting character of the pea plant. (use Table 4.1)

Denote the pure bred dominant plant and the pure bred recessive plant using suitable symbols.

Show the pattern of inheritance in a mono-hybrid cross, by a diagram.

The gene concept about hereditary characters

Mendel stated that characters of organisms are determined by certain 'particulate factors'. These factors are transmitted from parents to offspring through male and female gametes. He further stated that during gamete formation in organims, these factors get separated (segregated) and travel to the gametes. The factors were later named as **'genes'**. In clarifying the gnene concept of hereditary characters, we denote the dominant character in capital letters and the recessive character in simple letters.

For a particular character, if the pair of genes are similar, that organism is **homozygous** for that character. It can also be said that the organism contains homozygous genes.

For a particular character, if the pair of genes are dissimilar, that organism is **heterozygous** for that character. In this case, the organism contains heterozygous genes.

Example:

Let us say, the gene for round seeds is R, and the gene for wrinkled seeds is r,

Organisms with homozygous genes ⟶ RR and rr

Organisms with heterozygous genes ⟶ Rr

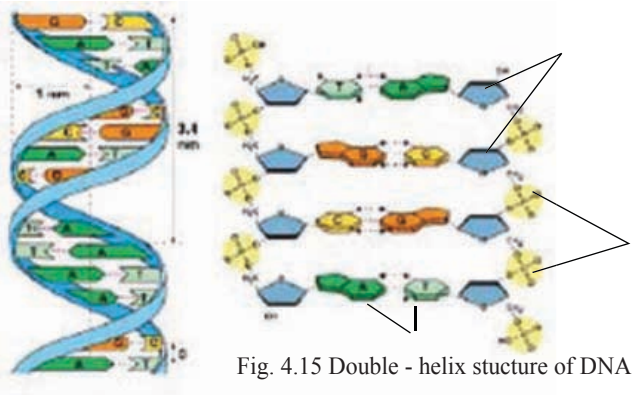
The way in which the pair of genes for a particular character is denoted is called the 'gene equation' of that organism.

Example: RR , rr , Rr

The character that is exhibited externally is called the **phenotype**. The genetic constitution of the organism which determined that character is called the **genotype** of the organism. Accordingly, in a pea plant with wrinkled seeds the phenotype is the wrinkled seed feature. Its genotype is Rr. The phenotype of the homozygous round seeded Pea plant phenotype is the round seeded character. It's genotype is RR.The phenotype of the homzygous wrinkled seeded Pea plant is the wrinkled character. It's genotype rr.

The new gene concept

It has been found that hereditary characters are transmitted from generation to generation through giant molecules called DNA present in chromosomes. A DNA molecule is a double helix with the two strands coiled around each other in the right handed direction. Each strand consists of sugar and phosphate groups. The double helix model of the DNA molecule was put forward by two scientists Watson and Crick.The two strands of the DNA molecule are joined by pairs of bases G-C and A-T.



A - Adenine base

T - Thyamine base

C - Cytosine base

G - Guanine base

Fig. 4.15 Double - helix stucture of DNA

These pairs of bases are found in different sequences. Characters of organisms are determined according to the way these pairs are found along the strand. A gene is a specific sequence of bases responsible for a particular character.

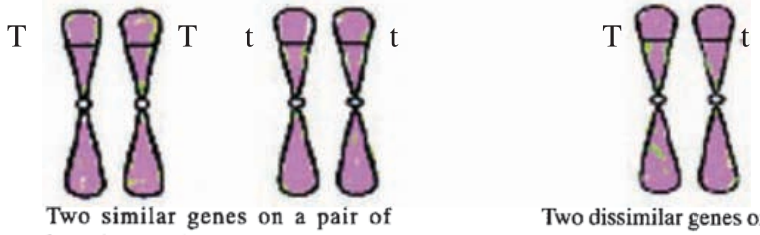
Transmission of characters by chromosomes

The genes for carrying on characters from one generation to the next is found on chromosomes. In the formation of a chromosome, a DNA molecule is coiled and the genes are found on the DNA.

The number of chromosomes in the nucleus of any particular species of organism is constant. Shown below are the numbers of chromosomes found in different species of organisms.

Organism	No. of chromosomes
Man	46
Chimpanzee	48
Horse	33
E. coil bacteria	01
Garden Pea	14
Paddy	24
Zea maize	20

Chromosomes are found in pairs according to their shape, size and other morphological characters. This shows that for each chromosome there is a corresponding chromosome. Such chromosome pairs which are similar to each other are called homologous chromosomes. In meiosis, it is these homologous pairs that come together at a certain phase of meiosis.



Two similar genes on a pair of homologous chromosomes.

Two dissimilar genes on a pair of homologous chromosomes

Fig. 4.16 Defferent ways of gene patterns on a pair of homologous chromosomes

Sex determination

Did you ever wonder what decided you to be a male or female? In the past it was believed that the woman was responsible for deciding the sex of the child. You will know that it is a false belief after an understanding the mechanism of sex determination. You already know that there are 23 paris of chromosomes in a somatic (vegetative) cell of a human being. Among these, the last pair of chromosomes is called the sex chromosomes. In the female each member in the pair of sex chromosomes is similar in shape and structure. They are known as X chromosomes. In the male, the members of the sex chromosomes are different. Hence they are called X and Y chromosomes. The Y chromosome is smaller than the X chromosome. But the X chromosome is similar to that of females.

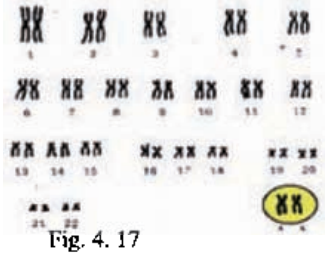


Fig. 4. 17

The 22 pairs of autosomes and the 23rd pair of sex chromosomes of females.

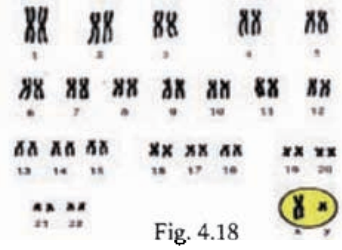


Fig. 4.18

The 22 pairs of autosomes and the 23rd pair of sex chromosomes of males.

You already know that female gametes are formed in female mother cells and that male gametes are formed in male mother cells. In gamete formation the pair of sex chromosomes separate. Therefore in a sperm or an ovum, there can be only one sex chromosome, of course in addition to the 22 autosomes i.e either X chromosome or Y chromosome.

Hence in an ovum, there is only an X chromosome , but in a sperm there can be either X or a Y chromosome only.

Accordingly, there are two kinds of sperms.

Sperms → Sperms with X chromosomes

Sperms → Sperms with Y chromosomes

When an ovum gets fertilized by a sperm, the nucleus of the zygote may have two X chromosomes or a X and a Y chromosome.

When there are two X chromosomes, the result is a female child and when there are X and Y chromosomes result is a male child. Hence it should now be clear that the necessary factor for a male child comes from the father. A figure showing only sex chromosomes will clarify how sex is determined.

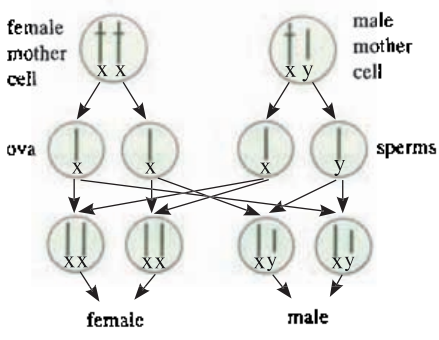


Fig. 4.19 how sex is determind

Assignment - 2

The ratio of male offspring to female offspring is 1:1. How will this proportion affect the population composition of a country? Collect relevant data about this and discuss with your teacher.

Importance of genetics to man

Deviations of hereditary characters from the Mendelian pattern.

During the inheritance of characters from generation to generation, there are instances when there are deviations from the normal pattern. Some such examples are?

- Gene linkage
- Incomplete dominance
- Mutations

1. Gene linkage

A pair of genes responsible for a particular character is found at similar positions in homologous chromosomes. That these genes separate independently was clear from Mendel's experiments. (4.1.20). Also we know that in a mono-hybrid cross, the phenotype of the F_2 generation was 3:1.

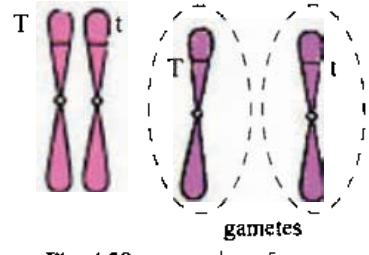


Fig. 4.20 segregation of genes during the formation of gametes

In experiments conducted later, it was found that different ratios were obtained in certain cases. Experiments conducted by Morgan confirmed that in certain cases, that genes could not separate independently. The reason for this was that such genes were found on the same chromosome and were linked to each other.

When two or more genes are linked on the same chromosome they are called linked genes.

In experiments with the two characters, body colour and wing- shape of *Drosophila* it was found that unexpected phenotype ratios were obtained.

The dominant and recessive genes for the above characters are as follows:

Body colour

Grey (G) - Dominant

Black (g) - Recessive

Wing shape

Long (L) - Dominant

Vestigeal (l) - Recessive

Consider a cross as follows:

P Long wing, grey body X Vestigeal wing, black body

F_1 Long wing, grey body 100%

P Long wing, grey body X Vestigeal wing, black body

F_2 Long wing, grey body X Vestigeal wing, black body

3 : 1

Fig. 4.21 linked genes of Drosophila

Here, the genes do not seem to have separated, but got transmitted together. Such genes are said to be **linked.**

When linked genes are present they do not segregate, but are transmitted together. A number of such linked genes may be present in any organism.

2. Incomplete dominance

There are times when none of the contrasting characters are dominant. Examples are *Mirabilis jalapa* and Snap dragon. A cross between the red variety and the white variety of *Mirabilis* produced only intermediate pink flowers in the F_1 generation. In the F2 generation obtained by self pollinating F_1 plants, red, pink and white flowers are obtained in the proportion of 1:2:1. (Fig 4.22)

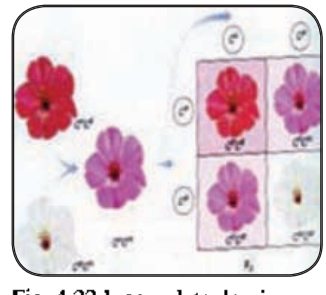


Fig. 4.22 Incomplete dominance in *Mirabilis jalapa*

According to Mendel, the prominent allele dominates over the recessive allele. In the above case it has not happened.

The heterozygous plants have an intermediate colour of pink.

The F_2 generation produces a different proportion from the expected 3:1 ratio. The reason for this situation is that the dominant character is not exhibited completely, showing incomplete dominance.

3. Mutations

Every gene is produced as a copy of a former gene. Hence every gene is identical to the mother gene. But sometimes genes that are different to the mother gene appear.

Such a phenomenon is called mutation. Certain mutations occur spontaneously without any external influence. Exposure to X-rays and certain chemicals also may cause mutations. The mutation occurring in a normal gene often causes it to be a recessive gene. In a population, these mutant genes may result in organisms with different phenotypes. Albinism is the result of a gene mutation of this manner.

a) Albinism

Albinism is the condition where the skin, hair and eyelashes of a person is an unusual white due to a mutation in the gene which produces the pigment needed to give the natural colour to the skin. Albinism is seen only in such persons who are homozygous to that gene. Albino animals can also be seen.

Fig. 4.23 Albino Cobra & Albino Monkey

Hereditary diseases among human beings

Certain disease conditions are caused by mutations in the genes. Such mutations can be seen in somatic chromosomes as well as sex chromosomes. The diseases that arise due to recessive genes linked to the sex chromosomes are called sex-linked characters. Let us consider some diseases associated with autosomes.

- **Thalacemia**

Thalacemia is the condition where the ability to produce haemoglobin which is the carrier for oxygen is hampered. This is due to the mutation of the gene which is responsible in producing haemoglobin. The main symptom among thalacemia patients is anaemia. This disease is more common among males.

- **Sickle cell anemia**

People suffering from this condition have red cells which are sickle shaped.(Fig.4.1.24). Because of this shape, these cells cannot carry the same amount of oxygen as a normal red cell. Therefore the patient suffers from lack of oxygen. This leads to extra pressure on the heart and the spleen. Such people often die before sexual maturity.

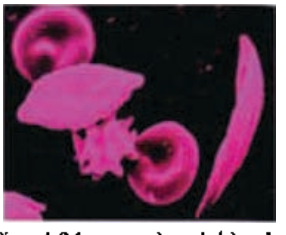


Fig. 4.24 normal red blood cells and sickle shaped red blood cells

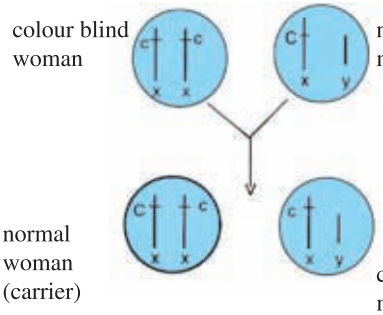
Now let us consider some diseases caused by sex-linked recessive genes.

- **Colour blindness**

This is the commonest sex-linked disease among humans. Such people are unable to distinguish red colour from the green colour. This condition is mostly seen among males. Very rarely is it seen in females. This condition is due to a recessive gene found in the X chromosome. It is manifested in females only if the recessive

gene is located in both chromosomes. But males get the disease even when the gene is located in only one X chromosome.

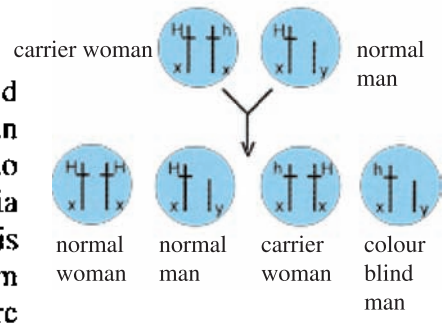
The X chromosome of the father is transmitted only to the daughter. But one of the pair of X chromosomes of the mother is transmitted to both daughters and sons. Hence if a woman suffers from colour blindness, even if she marries a normal person all her children whether girls or boys will be colour blind.



- All daughters are normal, yet due to the recessive gene they will be carriers.
- For a daughter to be colour blind, both her parents should be colour blind.

C - Dominant gene for the disease
c - Recessive gene for the disease

2. Haemophilia



It is essential that blood leaving the body should clot. People suffering from haemophilia can bleed to death, even by a slight wound due to the inability of his blood to clot. Haemophilia is caused by a sex-linked recessive gene. This is common among males. This too is carried from one generation to the next by females who are carriers. Although the above hereditary diseases are rare among females, female children of close blood relations can become victims of the disease

C - dominant gene for haemophilia
c - recessive gene for haemophilia

Importance of knowled scan genetics to humankind

All the varieties of vegetables we take as food today were, in the past found in the jungles as wild species. With the increase in population man has being able to improve the quality of these varieties by various breeding methods.

Fig. 4.27 Improved varieties of vegetables and fruits in the market

You may have been impressed by the size and quality of the different varieties of vegetables and fruits found in the market. If you could have seen the 'wild varieties' from which these were improved, the difference may be clear.

Assignment 3
Visit a vegetable market and identify the improved varieties found there. Report the special features in them (seedless, fleshy etc.)

With improved knowledge of genetics, new artificial breeding methods (hybridization), many improved varieties of vegetables, fruits cereals and pulses have been added to the food of people. If we were not able to produce food crops which give high yields in a short time, fruits of large size, resistant to pests and fungal diseases, easy to pack, providing sufficient food for the ever growing population would only have become a dream.

Fig. 4.28 Seedless Citrus fruits

In horticulture too, new varieties of flowers with new colours, longer keeping quality and ability for easier packing have been developed by artificial breeding methods.

The knowledge from genetics has enabled us to get new varieties of various cash crops such as coconut, pepper, cinnamon with high yields. The long journey in this field was pioneered by Mendel who has to be remembered with gratitude.

There is evidence that in the past too, farmers practiced selective breeding to improve the varieties of plants and animals and obtained stocks with improved qualities. However it was a practice of chance selection. With the development of genetics, production of new and improved varieties of plants and animals was done on a scientific basis.. Initially it was started by wheat farmers in America to improve their crops. With the discovery of pest resistant, high yielding varieties the entire economy of the country improved greately. In Sri Lanka too, the development of this field by the Food research institutes and breeding centres,is appreciable.

Disadvantages of artificial breeding

There is no doubt that the introduction of artificial breeding techniques has rendered invaluable service to the field of food technology. Yet the disappearance of valuable 'wild' genes in the original forms of these organisms poses a problem to the natural survival of the world. New species should arise as a result of natural selection. The artificial breeding methods of creating new species is completely contradictory to this process. Therefore the attempts of man to interfere with nature to develop new species is against the natural evolutionary process.

4.2 Evolution of organisms

Theories on the origin of life

How did life begin on earth? Were all of the organisms in existence today created by someone with all the differences seen in them? This kind of curiosity would have occurred to you too. Many theories have been put forward as explanation to this query.

Theory of Special Creation

According to this theory, all objects and organisms were created in the present form by some almighty power. This theory was not paid much attention by the scientists.

Theory of Spontaneous generation

According to this theory, living organisms arose from non-living matter spontaneously.

Scientists discarded this view on the basis of experimental data. There is also a theory that life came from outer space and got established on earth. Even today certain scientists believe this theory. They have put forward many hypotheses to confirm this.

Theory of evolution of organisms

This theory states that the present forms of organisms started as simple organisms which underwent series of changes to be the present forms. This series of changes was called evolution. Since this theory has been substantiated by experimental data, it is now accepted by the scientific community.

Many theories have been put forward to explain the mechanism on how evolution takes place. Some of them are given below.

1. Theory of use and disuse

The above theory put forward by Jean Baptiste Lamarck states that changes in the environment bring about changes in organisms, which according to whether they were used or not used would get established or get wiped out. He stated that characters acquired during the lifetime of an individual are passed on to new generations. He explained the appearance of the long neck of giraffe and the long ears of the rabbit on this theory.

Assignment 4

Find out the manner by which Giraffe got it's long neck according to the Law of use and disuse. Use resources on evolution.

2. Theory of natural selection

Charles Darwin, a French scientist put forward the strongest theory for evolution of organisms in his Theory of Natural Selection. (Fig.4.29). He went on a tour to the Galapagos islands in the Pacific ocean, and studied the various organisms found there. These islands were the home for a large range of organisms adapted for various environmental conditions. He collected many live specimens as well as fossils, and in the year 1859 enunciated the Theory of Natural Selection.

Fig.4.29 Charles Darwin

Fig.4.30 some fossils

Do you know?

Fossils are the natural prints 'foot prints in the sands of time' left by those organisms which lived in the distant past. Fossils are of different forms. Some of them are organisms preserved in plant resins, Pieces of bones, teeth etc. preserved in sedimentary soil, or imprints left as the parts decayed, or footprints left in mud which later got covered by layers of soil over them.

Charles Darwin made use of the following observations when developing his theory.

- Number of organisms in a population remains more or less constant in spite of increase due to reproduction.
- Certain organisms which lived in the past have become extinct.
- The organisms living in the island of Galapagos show similarities as well as differences to the organisms in the nearby continent.

The above features were particularly noticed among many varieties of Finches living in the island. Although they were similar in most respects, they differed in the shape of their beaks. See Fig.4.31. This was because the types of food in the different islands varied appreciably.

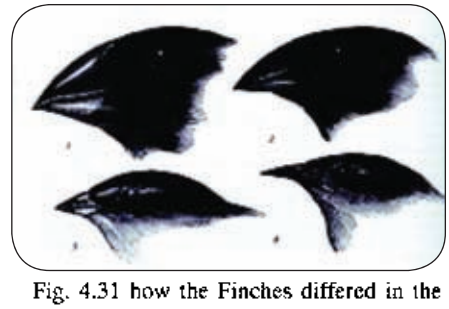


Fig. 4.31 how the Finches differed in the shape of their beaks

The Theory of Natural Selection was based on two important observations of populations of organisms. They are,

(1) Over production

(2) Variations

Based on these, Darwin forwarded the following hypothesis, that among organisms there is,

(1) Struggle for existence

(2) Natural selection

(3) Survival of the fittest

Let us examine each of these in detail.

1. Over production

Organisms produce a large number of offspring during their lifetime. It is over production. This is valid for both plants and animals. A 'Thampala' plant (a herb) produces thousands of seeds in an year. If all these seeds are to germinate how many plants would be there? How many plants would be produced in the next generation?

A garden snail produces thousands of eggs at a time. If all the snails coming out of these eggs were to survive till maturity there would be an enormous number of snails in the next generation. But it was observed that plants or animals do not produce offspring in this manner. The main reason for this was that many of them did not survive till the reproductive age.

2. Variations

Variations are differences among individuals. Characters are determined by genes. The offspring get half of these genes from the mother and half from the father. Hence offspring are bound to be a little different from the parents. There is another way by which variations occur among offspring, that is due to mutations. Hence in a population of organisms individuals with many variations can be seen.

Fig. 4.32 the lamb who has short legs is also a variation

3. Struggle for existence

Organisms compete with one another for many needs such as food, water, air, space in their environment, throughout their lifetime. Plants in addition compete for light. Among these organisms only those who are successful will survive till the reproductive age. Those who fail will die. Competition controls the growth in numbers of a population.

4. Survival of the fittest

In the competition for resources of the environment those organisms who are better suited for the environment, that is those with better variations are at an advantage. These are recorded in their genes. Such organisms will remain in that environment. Those with characters which are not suited to the environment will become extinct. The characters which are more suitable will be transmitted to the next generation through genes. After a period, the majority of organisms in that population will be those with the more suitable characters. Continuation of this process will result in new variations which are different from the previous generation.

Since the more suitable variations have been selected by the environment, this process is called "natural selection". Hence it is the environment which selects the organisms that should survive.

Examples of natural selection

1. *Biston betularia* variety of moth

The natural selection of a moth variety is a good example of natural selection which occurred in Manchester in England. Two varieties of these moths are found, that is those with white wings and those with black wings. (Fig. 4.3) In England, before the industrial revolution, the large trees had trunks covered with whitish lichens. Therefore when the white moth variety were resting on them they were not easily seen by predator birds. But the black variety was more easily seen, and more easily preyed upon. Therefore, before the industrial revolution the population of the white variety was more.

Fig. 4.33 Varieties of Biston betularia

But the pollution caused by smoke from factories destroyed the lichens while the tree trunks got black due to soot. Can you predict the changes that occurred in the moth population due to the environmental change?. The white variety was the more prominent against the soot coverd trunks. The black variety was camouflaged and escaped predation. Result was an increase in the black population.

Assignment 5

Prepare a report including the hypothesis about the effect of environmental pollution on *Biston betularia*. Discuss with your teacher.

According to the Natural selection theory, this phenomenon could be explained as follows.

Many varieties among the moths	-	Variations
↓		
Competition to escape predation	-	Struggle for existence
↓		
Increase in the black population which is more suited to the environment	-	Survival of the fittest

3. D.D.T resistant mosquito varieties

During the latter part of 1930, whole of Sri Lanka was devastated by an epidemic of Malaria. The vector for this disease was a variety of mosquito, Anopheles. This disease was completely eradicated with the use of the pesticide, D.D.T. It was acclaimed by the World Health Organisation as a success story. The spraying of D.D.T was discontinued. 5 years later Malaria raised it's head again. How did this happen? Here too, natural selection operated.

Malaria resistant varieties in the population	-	Variations
↓		
Competition for survival from the pesticide	-	Struggle for existence
↓		
Increase in the D D T resistant variety which were now more suited.	-	Survival of the fittest

(Here the selection factor was D D T pesticide.)

The mosquitoes which already had the D D T resistant character were able to survive, causing an increase in their variety in the population. The increase after 35 years was due this variety increasing in numbers. Hence a stronger pesticide, Malathion had to be used.

Neo-Darwinism

The Darwinian theory was reappraised in terms of modern genetics as Neo-Darwinism. At the time when Darwin formulated his theory there was no knowledge oh heredity. Also Mendel's findings about inheritance were not published. Therefore Darwin had two major problems.

- Inability to explain how variations occurred
- Inability to explain how parental characters were transmitted to offspring

But now;

Neo-Darwinism has incorporated the new findings from genetics and molecular biology.

Appearance of variations are explained on the basis of mutations. You have already learnt how mutations take place due to the changes occur in DNA molecule and due to the changes occur in chromosomes.

At the time Darwin postulated his theory of evolution, if he knew about chromosomes, genes and DNA he surely would have said the following:

"In a changing environment, only those organisms which are suited to the environment will survive. Such survivors will pass on their genetic material, that is DNA to their offspring. After a long time a totally new species of organisms will be evolved. Organisms with more suited genetic variations will not only live longer, but also will produce a large number of offspring with such characters."

Continuation of evolution

Evolution of plants and animals are taking place even today. Why we do not see it happening is because it is a very slow process. Man too is subject to the process of evolution. Scientists believe that human evolution is taking place over around 50,000 years. The Fig. 4.34 shows the long journey of man in evolving from ape to modern man.

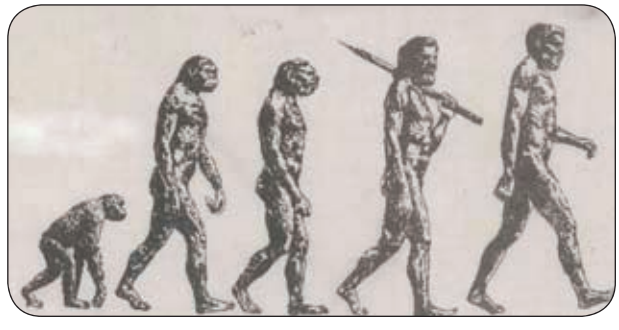


Fig.4.34 human evolution

Assignment 6

Illustrate by a drawing or by words, the form of the 'human being' that may come into being in the distant future, as a consequence of the environmental conditions prevailing at present. (Hint: Modern man makes little use of his limbs due to machines, but more use of his brain).

Exercises

A) Select the correct answers.

1. If it is needed to obtain Tall plants and Short plants in the ratio of 3:1, by crossing the offspring of an F1 cross between a pure bred tall plant and a pure bred short plant, what is the procedure you should adopt?
   i. Cross F_1 hybrids with pure bred tall plants
   ii. Self pollinate F_1 hybrids
   iii. Cross pollinate F_1 hybrids
   iv. Cross pollinate F_1 hybrids with pure short plants.
2. When antibiotics are used for bacterial infections, it has being noticed that new varieties of bacteria resistant to the antibiotics are formed. The reason for this may be
   i. Antibiotics caused mutations in the bacteria
   ii. Antibiotics acted as a selector.
   iii. Antibiotics became weaker

B)

1. Which one of the phenomena given below are example of natural selection?
   i. Getting a new improved variety of paddy by crossing two varieties of paddy.
   ii. Increase in the population of resistant varieties of insects due to spraying of pesticides.
   iii. Drop in the harvest due to an increase in the Brown insect population.
   iv. White moths on a grey background being preyed upon by birds.
2. The antibiotics such as Penicillin and Streptomycin used originally were successful for controlling many bacterial infections. But later , since they were not effective, new stronger antibiotics had to be discovered. How do you explain this phenomena in terms of natural selection?