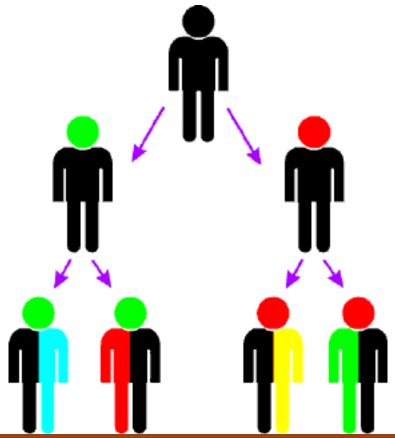
Chapter

8

Heredity - From parent to progeny



When we observe our world and its myriad forms of life, we are struck by two seemingly opposite observations, the fantastic variety of life and the similarity between them. As we shall see, we would need to understand these two characteristics of life in order to understand how life evolves. When we say that something evolves, we mean not only that it changes, but that there is also some component of direction in that change.

But, how does evolution take place? Does it occur in a slow and steady manner or in quick jumps? Is it just about change and producing something new and different?

In the chapter on reproduction we had studied that reproductive processes usually give rise to individuals that have some new characters in spite of the similarity that they share with their parents. Often such new characters give rise to observable changes in life forms.

- *How are new characters produced?*
- *Are they inherited?*
- *Do they have any role in the process of evolution?*

In this chapter we shall try to explore several such questions.

New characters and variations

Think of your own family, what similarities do you share with your father and your mother? Draw a table to represent the similarities of some characters like colour of eye(cornea), colour of hair, shape of nose, shape of face, type of ear lobe(attached or free), inner thumb markings etc. Write your characters and that of your parents in two separate other columns.

- *How many similar characteristics do you find among you and your parents?*
- *Is there any character in you that is neither like your father nor like your mother?*
- *Where do you think you got such a character from?*

Let us do an activity to find out more about this.

Activity-1

Compare your traits with the traits of your parents and grand parents by drawing a table as given below in your notebook.

Table-1

Characters	In me	In my Mother/ Father	In my grandma / grandpa

- *Is there any character in you similar to that of your mother as well as your grandma?*
- *Is there any character in you similar only to that of your grandma?*
- *How do you think these characters may have been inherited by you from grandma?*
- *Is there any character that is not present in grandma but present in your mother and you?*
- *Think where from your mother got that character?*

Activity-2

Observe some of your friends and note their characters in the following table. Fill in yours as well.

Table-2

Name of your friend	Colour of skin	Ear lobes Free/ attached	Marking on inner side of thumb	Length of fore head	Colour of eyes (Cornea)	Any other features

- *Compare your characters to that of any one of your friend. How many characters did you find were similar among you and your friend?*
- *Do you share more similar characters with your parents or with your friends?*
- *Do you think that your differences from parents are same as differences from friends? Why /why not?*

fig-1: Variations in organs

Differences in characters within very closely related groups of organisms are referred to as variations. Often a new character in a group may lead to variations that are also inherited.

- *Is variation all about apparent differences?*

Is it about some subtle differences as well that we most often overlook? (Remember looking for two similar neem /doob grass plants in the chapter on diversity and classification in class IX)

Activity-3

Observe seeds in a pea or bean pod. You may observe several parts to arrive at a generalisation.

- *Can you find two similar seeds there?*
- *What makes them vary?* (Hint: You know that seeds are formed from ovules)
- *Why variations are important? How are variations useful for an organism or a population?*

Over centuries variations and their role in nature have been studied by naturalists. During early 19^{th} century, a lot of work was done by several scientists. Some of these studies will help us to understand how variations occur and are transferred from one generation to the next. We shall study a detailed account of experimental evidences provided by Mendel in the early 19^{th} century who is known as 'father of genetics'.

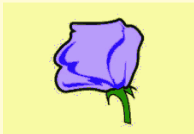
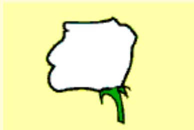
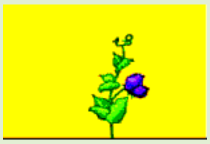
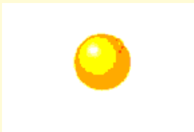
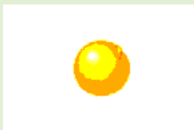
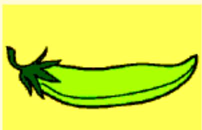
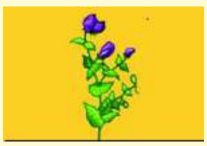
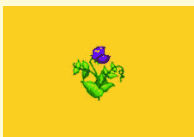
In 1857 Gregor Johann Mendel started working on the problem of how variations were passed from one generation to the other. Mendel did not do his experimental work either in a University or in a Laboratory. As he was a monk in a monastery he simply did his experiments in the monastery garden. He worked for over seven years after which he presented the conclusions from his experimental data in the form of a detailed research paper.

Mendel made many careful observations of plants and found that pea plants would be most suitable to carry on futher experimentation. Then he planned and designed the experiments to find out the answers to questions that came to his mind. He had worked on nearly 10,000 pea plants of 34 different varieties.

fig-2: Gregor Johann Mendel

Observing pea plants carefully, Mendel noted that they differ from one another in many ways. For example plants were tall or dwarf, seed shape round or wrinckled, seed cover (cotyledon) colour yellow or green. Thus, Mendel had chosen 7 pairs of contrasting characters for his study as shown in the table-2.

1. The difference in the form of the ripe seeds. These are either round or deeply wrinkled.
2. The difference in the color of the seed albumen (endosperm). The albumen of the ripe seeds is either pale yellow, bright yellow and orange coloured, or it possesses a more or less intense green tint. This difference of colour is easily seen in the seeds as their coats are transparent.
3. The difference in the colour of the seed coat. This is either white, with the character of white flowers are constantly correlated, or it is grey, grey-brown, leather-brown, with or without violet spotting.
4. The difference in the form of the ripe pods. These are either simply inflated, not constricted in places, or they are deeply constricted between the seeds and more or less wrinkled.
5. The difference in the colour of the unripe pods. They are either light to dark green, or vividly yellow.
6. The difference in the position of the flowers. They are either axial, that is, distributed along the main stem, or they are terminal, that is, bunched at the tip of the stem.
7. The difference in the length of the stem. The length of the stem is varied in some forms. In experiments with this character, in order to discriminate with certainty, the long axis of 6 to 7 feet. was always crossed with the short one of $^3/_4$ to $1^1/_2$ feet. (Popularly called the tall and dwarf varieties.)

Table-3: The results of Mendel's F1 crosses for seven characters in pea plants				
Character	**Dominant Trait**	**Recessive Trait**	**F2 Generation** **Dominant: Recessive**	**Ratio**
Flower colour	Purple 	White 	705:224	3.15:1
Flower position	Axial 	Terminal 	651:207	3.14:1
Seed colour	Yellow 	Green 	6022:2001	3.01:1
Seed shape	Round 	Wrinkled 	5474:1850	2.96:1
Pod shape	Inflated 	Constricted 	882:299	2.95:1
Pod colour	Green 	Yellow 	428:152	2.82:1
Stem length	Tall 	Dwarf 	787:277	2.84:1

Mendel hypothesized that characters were carried as traits and an organism always carried a pair of factors for a character. He also hypothesized that distinguishing traits of the same character were present in the population of an organism. He assumed that the traits shown by the pea plants must be in the seeds that produced them. The seeds must have obtained these traits from the parent plants.

How do parent plants pass on their traits to the seeds? Will the seeds from tall plants always produce new tall plants?

Mendel carried out several experiments to find out answers to such type of questions.

Examples of experiments performed by Mendel

The following section shows number of experiments performed, number of fertilizations carried out and the number of plants involved in the study.

1. 1^{st} experiment 60 fertilizations on 15 plants.
2. 2^{nd} experiment 58 fertilizations on 10 plants.
3. 3^{rd} experiment 35 fertilizations on 10 plants.
4. 4^{th} experiment 40 fertilizations on 10 plants.
5. 5^{th} experiment 23 fertilizations on 5 plants.
6. 6^{th} experiment 34 fertilizations on 10 plants.
7. 7^{th} experiment 37 fertilizations on 10 plants.

- *Why Mendel had choosen garden pea as material for his experiments?*

  Because it has following advantages.

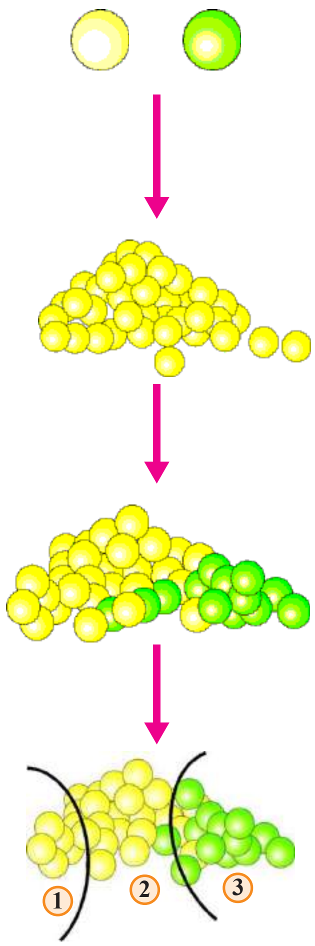
  1.Well defind characters, 2.Bisexual flowers, 3.Predominently self fertilization, 4.Early hybridization

Mendel selected such kinds of plants that expresses a selected character over several generations. Such plants according to him were pure breed for that character. Mendel did the experiment with two pure breeds of peas for seed colour contrasting characters yellow and green, and they are represented as yellow with 'Y' and green with 'y'. He started cross fertilizing pure breeds having contrasting characters.

Mendel started with two pure breeds of peas with different properties. We here take as an example a characteristic colour of the pea seeds yellow and green.

Do you know?

Pea is an annual plant, with a life cycle of one year. It is a cool season crop grown in many parts of the world. Peas were present in Afghanistan in 2000 BC, in Harappa, Pakistan, and in northwest India in 2250–1750 BC. In the second half of the 2nd millennium BC, this pulse crop appeared in the Gangetic basin and southern India. Pea contains vitamin 'A, C, E, K & B' and minerals like Ca, Fe, Mg, Mn, P, S & Zn.



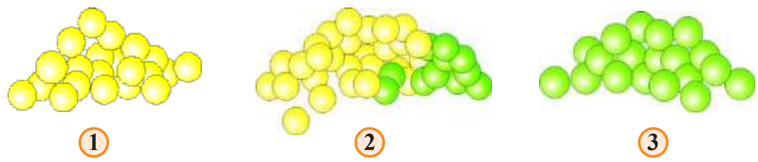
Cross pollinating a pure breed of yellow and green gave

First Filial (F1) generation (Mendel called it as first filial or progeny of first generation parents. Filial means progeny.)

All pea seeds were Yellow. These pea plants on self pollination gave

Second Filial (F2) generation [About 75% yellow (seeds) peas and about 25% green (seeds) peas.]

Third Filial (F3) generation (Mendel self pollinated these pea plants too, and found out that



1. A set of peas (about 25%) gave only yellow seed giving pea plants.
2. Rest of the yellow seed giving pea plants gave about 75% yellow and about 25% green seed giving pea plants.
3. The set of green peas gave only green seed giving pea plants.

Mendel made some assumptions by which he could explain his observations.

Assumption 1: Every pea plant has two 'factors' which are responsible for producing a particular character or trait. The determining agent responsible for each trait is called a factor.

Mendel carefully choose the plants which did not produce a mixed result (pure). In our example of yellow and green peas, a pure breed (parental stage) will have both the 'factors' of the same type.

A pure breed (parental) yellow seed giving pea will have both the 'factors' of the same type. Let us denote them by 'Y'.

A pure breed (parental) green seed giving pea will have both the 'factors' of the same type. Let us denote them by 'y'.

Assumption-2 : During reproduction one 'factor' from each parent is taken to form a new pair in the progeny.

Assumption-3 : One of these will always dominate the other if mixed together. The trait expressed in F1 generation was called dominant. While the other which did not express was called recessive.

Assume that 'Y' (the one causing yellow colour) is a dominating 'factor'. That means if 'Y' and 'y' come together 'Y' will dominate. Then the pea seeds will be always yellow in colour.

Parental generation - Cross pollination

From assumption-2, the breed after cross pollination will have one factor from pure breed yellow (Y) and one from the pure breed green (y). That is, all the peas will have the paired factor 'Yy' and by assumption-3 all the peas will be Yellow as 'Y' factor is dominant.

♀ \ ♂	y	y
Y	Yy	Yy
Y	Yy	Yy

Yy .... (yellow)

Yy .... (Yellow)

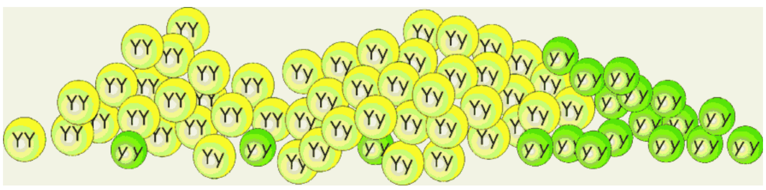
Yy .... (yellow)

Yy .... (Yellow)

All the pea plants are yellow (F1-Generation). The trait expressed in F1 is dominent, unexpressed is recessive. This is the law of dominenance.

Self pollination in F1-Generation

On self pollinating these peas (ones with Yy factor), the new breed have any combinations of 'Y' and 'y'.



♀ \ ♂	y	y
Y	YY	Yy
y	yY	yy

It can be YY, Yy, yY or yy. All of them are in equal ratio.

So in this heap we will get approximately equal number of YY, Yy, yY and yy peas. But any pea that has a Y factor will be yellow. Any pea that has both yy will be green. Since all combinations are equally likely:

1. YY will be approximately 25% and is yellow.
2. yY will be approximately 25% and is yellow, Yy will be approximately 25 % and is yellow
3. yy will be approximately 25% and is green.

Some seeds appear yellow in colour in F1 generation. When these seeds were sown some of the plants produced green coloured seeds. So we can't determine internal character based on external visible character.

Phenotype

Thus in F1 generation we can clearly observe that 75 percent are yellow seed producing pea plants and 25 percent are green ones. This is known as 'Phenotype'(externally visible characters) and this ratio is called 'phenotypic ratio' is 3:1.

Genotype

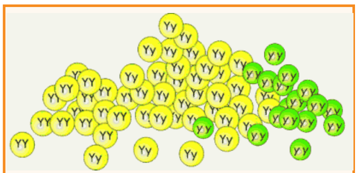
Genetically, in 75 percent yellow seed producing pea plants only 25 percent pea plants produce yellow seeds that are pure breeds (YY) and are 'homozygous' that is to have the same factors for representing a character. Remaining 50 percent yellow seed producing pea plants are (Yy) heterozygous . The remaining 25 percent green seed producing pea plants are pure (yy) homozygous type.

The constitution of pea plants as shown by the representative letters Y and y to show the probable nature of factors is known as genotype. This ratio is known as genotypic ratio is 1:2:1

On self-pollinating these peas of F2 generation we get,

♀ ♂	Y	Y
Y	YY	YY
Y	YY	YY

1



♀ ♂	Y	y
Y	YY	Yy
y	yY	yy

2

♀ ♂	y	y
y	yy	yy
y	yy	yy

3

1. The YY peas will on self pollination give only yellow (YY) peas. This was explained with the experimental result that this set gave 100% yellow peas.
2. The Yy or yY peas on self pollination give about 75% yellow peas and about 25% green peas. This situation is same as step 2 ratio 3:1.
3. The green peas that contain yy factors will give only green peas.

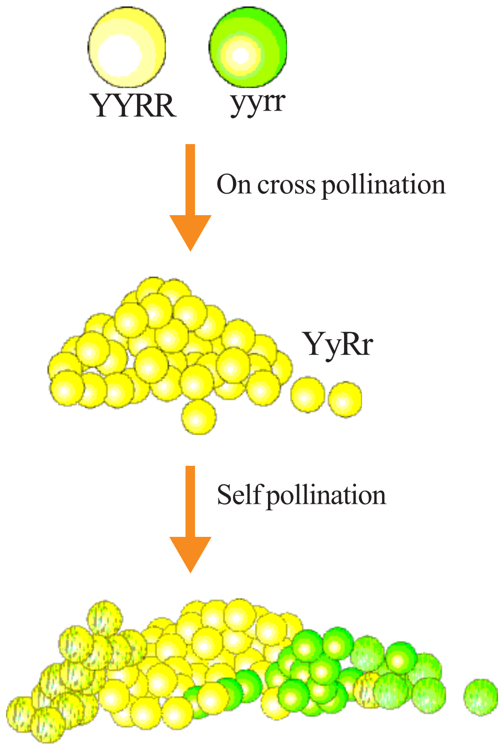
   In nature there are many factors responsible for different properties.

- Can we test our hypothesis with more than one factor?

  How can this be applied to Mendel's experiment? This can be done together when two pairs of contrasting characters are taken into consideration.

1. Colour of peas-yellow and green symbolically indicated as ‘Y’, ‘y’.
2. Shape of peas-Round and wrinkled symbolically indicated as ‘R’, ‘r’.

The plants with yellow and round seeds (pure) were crossed with those having green and wrinkled seeds (pure).



All pea seeds that were yellow and round skin. Each pea will have factors ‘YyRr’.

Since Yellow colour (Y factor) and round skin (R factor) are dominant traits. All the pea seeds will be round and yellow (F1 generation).

He got in F2 generation some seeds were round and yellow (YyRr or YYRR), some seeds were round and green (yyRR or yyRr), some seeds were wrinkled and yellow (Yyrr or Yyrr), and some seeds were wrinkled and green (yyrr).

- *What should be the percentage of each type?*

Mendel explained the process of inheritance of more than one pair of characters. This law is known as law of independent assortment. We will learn more about this in further classes, for the basic understanding refer in annexure.

Mendel propounded that, among a pair of closely related ‘alleles’ or factors for a character, only one expresses itself in the first generation as one of the allele is dominant over the other. This is so evident that it came to be called as Mendels’ Law of Dominance.

He also stated that, every individual possesses a pair of alleles (assuming only a pair is present) for any particular trait and that each parent passes a randomly selected copy (allele) of only one of these to an offspring. The offspring then receives its own pair of alleles for that trait one each from both parents. This is what Mendel called ‘segregation’ and it is the Law of Segregation.

Traits that may be passed on from one generation to the next are called as heritable traits. We have studied some of them for the pea plant, in the experiments conducted by Mendel.

Activity-

Let us do the following activity to understand the Mendelian principles of Heredity.

♀ ♂	BAG 'A'			
BAG 'B'	1	2	3	4
	5	6	7	8
	9	10	11	12
	13	14	15	16

Materials required :

a) 3 cm length and 1cm breadth chart pieces- 16

b) 2 cm length and 1cm breadth chart pieces- 16

c) Red buttons - 16

d) White buttons - 16

e) Chart, scale, sketch pen, pencil, 2 bags.

Method: Prepare a chart with 4×4 boxes along with number and Symbol as shown in the figure

Game 1: Monohybrid cross (starting with hybrid parents)

To start with take 1,2 or 3,4 . In case you start 1,2 pick all the 16 long and short pieces and prepare such pairs in each of which you have a long and short piece.

Take 8 pairs each of long and short strips and put them in two separate bags. Now each bag contains 16 strips (8 long and 8 short).One bag say 'A' represents male and the bag 'B' represents female. Now randomly pick one strip each from bag A and B and put them together in the 1 on the chart. Keep picking out the strips and arrange them in the same manner till your bags are empty. Sametime your boxes in the chart are filled with pairs of strips. You might have got the following combinations, two long strips, one long and one short strip, two short strips.

- *What is the number of long strip pairs?*
- *What is the number of one long and one short pairs?*
- *What is the number of short strips pairs?*
- *What is the percentage of each type? also find their ratios?*
- *What can you conclude from this game?*

You may play this game by taking buttons instead. Compare your second game results with that of first game. What do you understand. Try to play another game mentioned in annexure then discuss with your classmates.

Parent to progeny

A person resembles his grandfather, a girl seems to be a photocopy of her aunt, generally we hear such comments. These similarities are the result of inherited traits transmitted from parent to progeny. Let us do the following activity to understand inherited traits in human beings.

According to Mendel traits like the colour of seed, seed coat, length of stem etc. were heritable traits from parental generation.

Transmission or passing of characters or traits from parent to offsprings is called **'Heredity'**.

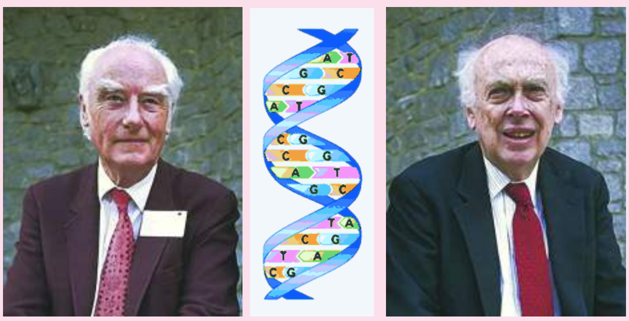
The process in which Traits are passed from one generation to another generation is called 'Inheritance'.

How do traits get expressed?

Mendel hypothesised that each character or trait is expressed due to a pair of factors or 'alleles' (contrasting expressions of the same trait), as he named them. Now we know that these are known as 'genes'. Gene is a segment of a nucleic acid called 'DNA' which is present in the nucleus of every cell. It controls the expression of a trait or character. In vireses RNA can also be controlling the expression of a character.

Do you know?

In 1953 the detailed structure of DNA was finally worked out at Cambridge by Francis Crick and James Watson. They discovered that DNA molecule looks rather like a spiral stair case, having a shape known as a double helix. The framework of stair case consists of alternate sugar and phosphate groups and the steps which join the framework together are the pairs of chemical compounds called bases. They are adenine, guanine, thymine and cytosine. Watson and Crick were awarded Nobel prize jointly with Franklin and Maurice Wilkins.

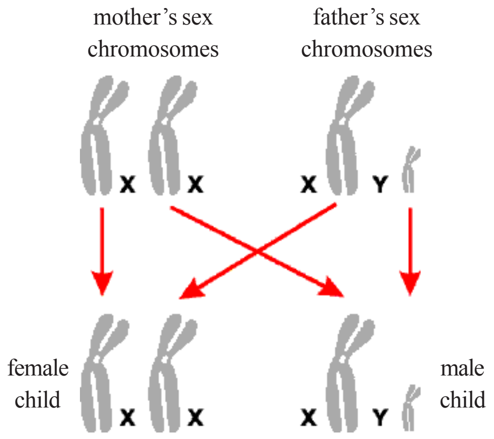


Watson *DNA* *Crick*

fig-3:

Traits are determined by the chemical nature of DNA and a slight change in it leads to variations. Colour of the hair, the skin etc. are examples of trait. Slight inheritable changes in the chemical structure of DNA may lead to change in the characteristic or trait of offspring of an organism, which leads to 'Variations'.

Sex determination in human beings



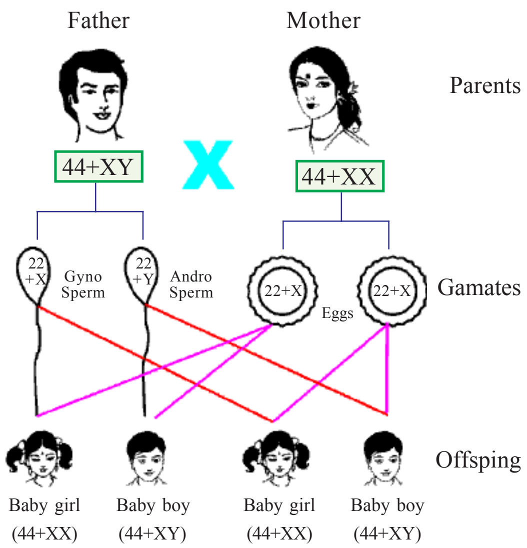


fig-4:

We inherited our traits from our parents. Let us see how sex is determined in human beings. Each human cell contains 23 pairs (46) of chromosomes. Out of 23 pairs 22 pairs of chromosomes are autosomes.

Chromosomes whose number and morphology do not differ between males and females of a species are called autosomes. The remaining pair is called allosomes or sex chromosomes. These are two types, one is 'X' and the other is 'Y'. These two chromosomes determine the sex of an individual. Females have two 'X' chromosomes in their cells (XX). Males have one 'X' and one 'Y' chromosomes in their cells (XY). All the gametes (ova) produced by a woman have only X chromosomes. The gametes (sperm) produced by a man are of two types one with X chromosome and other Y chromosome. If the sperm carries Y chromosome and fertilizes the ovum (X chromosome). Then the baby will have XY condition. So the baby will be a boy.

- *What will happen if the sperm containing Y chromosomes fertilizes the ovum?*
- *Who decides the sex of the baby – mother or father?*
- *Is the sex also a character or trait? Does it follow Mendels' law of dominance?*
- *Were all your traits similar to that of your parents?*

Do you know?

Discovery of the sex chromosomes

Walter Setton and Thomas Hunt Morgan in the year 1910 studied on a small fruit fly (Drosophila melanogaster) at Columbia University. The discovery of sex linked traits in Drosophila indicated that genes are on chromosomes. They worked out the details of inheritance in Drosophila.

Evolution

Variations develop during reproduction in organisms. Sexual reproduction and errors in DNA copying leads to variations in offsprings in a population. Let us try to study the consequences of variations in the population of an insect in an environment.

Activity-3

Variations in beetle population

Observe the below diagram showing variation in beetle population and it its impact.

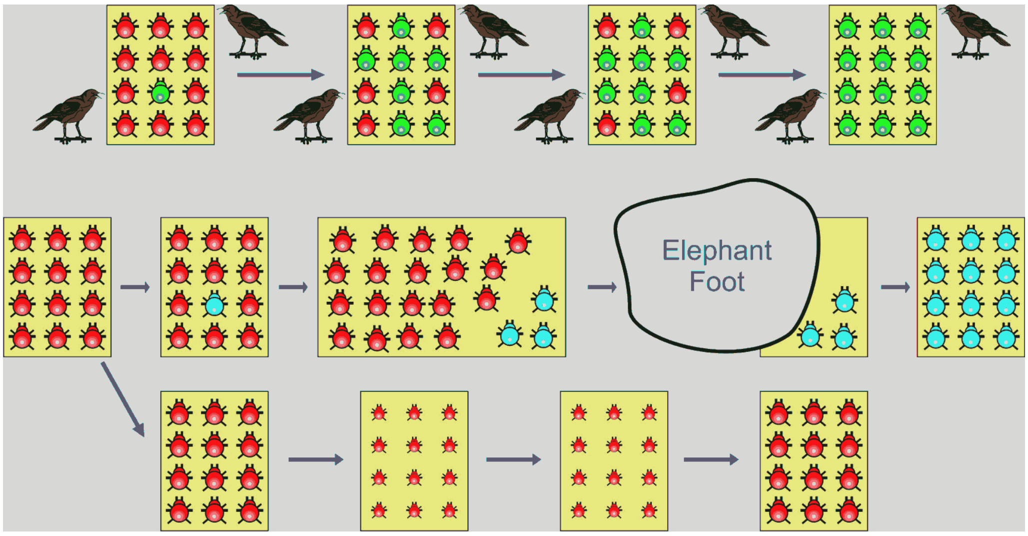


fig-5: Variation in population

Let us consider a group of twelve beetles. They live in bushes on green leaves. Their population will grow by sexual reproduction. So they were able to generate variations in population. Let us assume crows eat these red beetles. If the crows eat more Red beetles their population slowly reduced.

Let us think of different situations.

Situation-1:

In this situation a colour variation arises during reproduction. So that there appears one beetle that is green in colour instead of red.

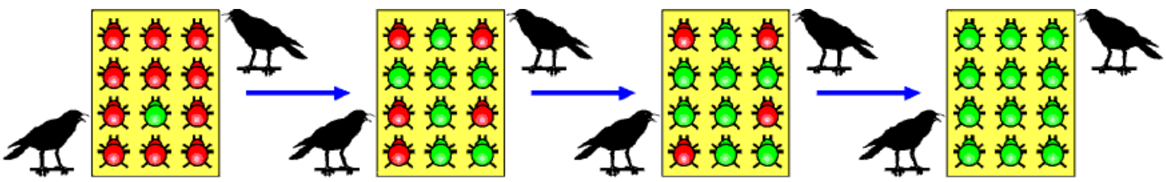


fig-6: Red and green beetles

More over this green coloured beetle passes it's colour to it's off spring (Progeny). So that all its progeny are green. Crows cannot see the green coloured beetles on green leaves of the bushes and therefore crows cannot eat them. But crows can see the red beetles and eat them. As a result there are more and more green beetles than red ones which decrease in their number.

The variation of colour in beetle 'green' gave a survival advantage to 'green beetles' than red beetles. In other words it was naturally selected. We can see that the 'natural selection' was exerted by the crows. The more crows there are, the more red beetles would be eaten and the more number of green beetles in the population would be. Thus the natural selection is directing evolution in the beetle population. It results in adaptation in the beetle population to fit in their environment better.

Let us think of another situation.

Situation-2:

In this situation a colour variation occurs again in its progeny during reproduction, but now it results in 'Blue' colour beetles instead of 'red' colour beetle. This blue colour beetle can pass its colour to its progeny. So that all its progeny are blue.

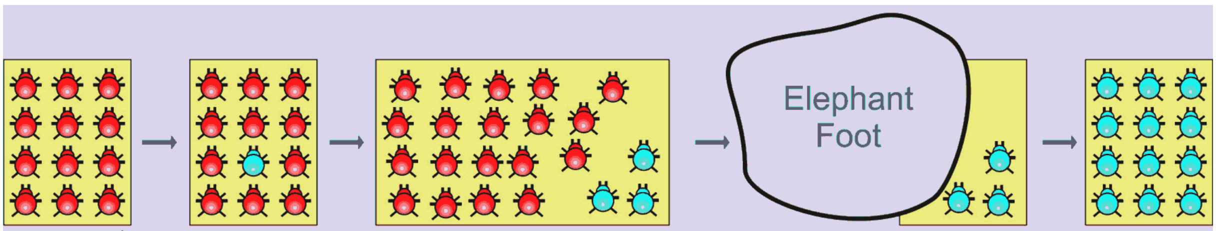


fig-7: Blue and red beetle

Crows can see blue coloured beetles on the green leaves of the bushes and the red ones as well. And therefore crows can eat both red and blue coloured beetles. In this case there is no survival advantage for blue coloured beetles as we have seen in case of green coloured beetles.

What happens initially in the population, there are a few blue beetles, but most are red. Imagine at this point an elephant comes by and stamps on the bushes where the beetles live. This kills most of the beetles. By chance the few beetles survived are mostly blue. Again the beetle population slowly increases. But in the beetle population most of them are in blue colour. Thus sometimes accidents may also result in changes in certain characters of the a population. Characters as we know are governed by genes. Thus there is change in the frequency of genes in small populations. This is known as "Genetic drift', which provides diversity in the population.

Let us think of another situation:

Situation-3:

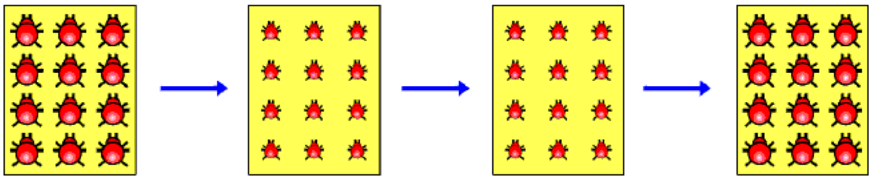


fig-8: Poorly nourished beetles

In this case beetles population is increasing, but suddenly bushes were affected by a plant disease in which leaf material were destroyed or in which leaves are affected by this beetles got less food material. So beetles are poorly nourished. So the weight of beetles decrease but no changes take place in their genetic material (DNA). After a few years the plant disease are eliminated. Bushes are healthy with plenty of leaves.

- *What do you think will be condition of the beetles?*

Acquired and Inherited Characters and Evolution

We discussed the idea that the germ cells of sexually reproducing population are formed in specialised reproductive tissue. If the weight of the beetles is reduced because of starvation, that will not change the DNA of the germ cells. Therefore, low weight is not a trait that can be inherited by progeny of a starving beetle. Therefore even if some generations of beetles lose their weight because of starvation, that is not an example of evolution, since the change is not inherited over generations. Change in non reproductive tissues cannot be passed on to the DNA of the germ cells. Therefore the experiences of an individual during its lifetime cannot be passed on to its progeny, and cannot direct evolution.

Lamarckism

In the olden days people believed that all the organisms on the earth had not undergone any change. Jean Baptist Lamarck was the first person to propose the theory of evolution. He thought that at some point of time in the history the size of giraffe was equal to that of deer. Due to shortage of food material on the ground and to reach the lower branches of trees giraffes started stretching their necks. Because of continuous stretching of neck, after several generations giraffes developed long necks. Such characters that are developed during the lifetime of an organism are called 'acquired characters'. Lamarck proposed that these acquired

fig-9: Jean Baptist Lamarck (1774-1829)

fig-10: Giraffee

characters are passed on to its offsprings i.e. to next generation and proposed the theory of 'Inheritance of acquired characters'. For example elongation of neck and forelimbs in giraffe.

But Augustus Weismann, tested this theory by an experiment on rats. He removed tails of parental rats. He observed that their offspring's are normal with tails. He has done it again and again for twenty two generations but still offsprings are normal with tails. He proved that the bodily changes are not inherited. So they won't be passed to it's offsprings.

Darwinism

Charles Darwin proposed 'Natural selection' the famous 'theory of evolution'.

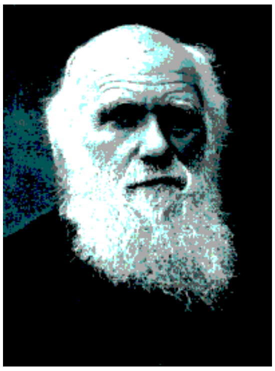


fig-11: Charles Darwin (1809 – 1882)

Charles Darwin (1809-1882) was born in England. He voyaged for five years, just when he was 22 years old. In the world survey ship HMS Beagle. He visited a number of places including Galapagos Islands. He keenly observed the flora and fauna of these places. He gathered a lot of information and evidences.

Darwin observed a small group of related birds which are exhibiting diversity in structure in the Galapagos islands. These birds are Finch birds. Observe the fig-12. How do the beaks help them.

He was influenced by the book 'Principles of geology' written by Sir Charles Lyell. He suggested that geological changes occured

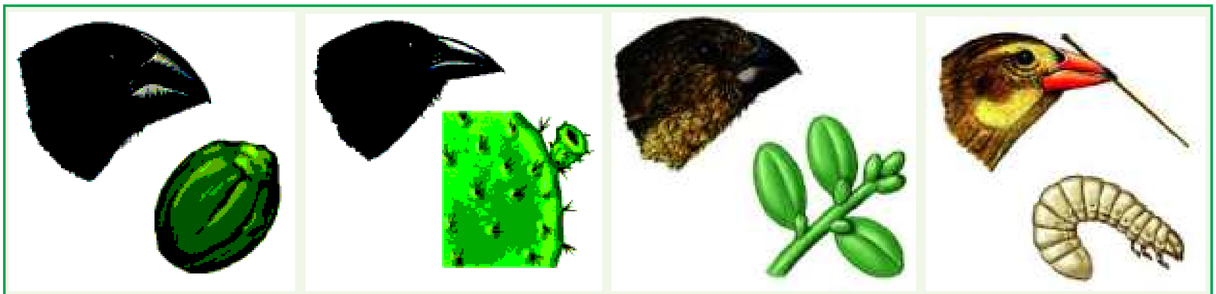


fig-12: Some Darwin finches

in a uniform rate, Darwin did not agree to this idea. He felt that large changes occured due to accumulation of small changes. Darwin was also influenced by the famous 'Malthus theory'. This was written in 'An essay on the principles of population'. Malthus observed that population grows in geometrical progression (1, 2, 4, 8, ...) where as food sources increases in arithmetic progression (1, 2, 3, 4, 5, ...).

Based on these ideas Darwin proposed the theory of "Natural selection", which means that the nature only selects or decides which organism should survive or perish in nature. This is the meaning of survival of the fittest. The organisms with useful traits will survive. If traits are not usefull to organisms then they are going to be perished or eliminated from its environment.

Alfred Russel Wallace also independently concluded that natural selection contributed to origen of new species. For example we have seen in the case of red beetles which were seen and eaten by crows. So, the population of red beetles gradually got eliminated or perished from its environment. But at the same time the beetles which are green in colour which are present on the green leaves were not noticed by crows. So the green beetles survived in the environment and their population have gradually increased. This is nothing but "natural selection".

Think and discuss

In a forest there are two types of deers, in which one type of deer can run very fast. Where as second type of deer can not run as fast as the first one. Lions, Tigers haunt deers for their food. Imagine which type of deers are going to survive in the forest and which type of deers population is going to be eliminated? And why?

Variations which are useful to an individual are retained, while those which are not useful are lost. In a population when there is a struggle for the existence the 'fittest' will be survived.

Nature favours only useful variations. Each species tend to produce large number of offsprings. They compete with each other for food, space, mating and other needs. In this struggle for existence, only the fittest can survive.

This is called 'survival of the fittest'. Over a long period of time this leads to the formation of new species.

You may observe in your surroundings some seedilings and some of the animal kids only survive. Discuss in your class based on those examples to understand survival of the fittest.

Darwin's theory of evolution in a nutshell

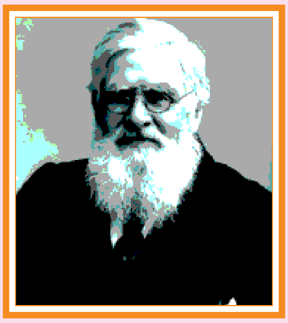
1. Any group of population of an organism developes variations and all members of group are not identical.
2. Variations are passed from parent to offspring through heredity.
3. The natural selection over abundance of offspring leads to a constant struggle for their survival in any population.

4. Individuals with variations that help them to survive and reproduce tend to live longer and have more offsprings than organisms with less useful features.
5. The offsprings of survivors inherit the useful variations, and the same process happens with every new generation until the variation becomes a common feature.
6. As the environment changes, the organism within the environment adapt and changes to the new living conditions.
7. Over a long period of time, each species of organism can accumulate so many changes that it becomes a new species, similar to but distinctly different from the original species. All species on the earth arise in this way.
8. Evolution is a slow and continuous process.

There are some limitations and objections to the Darwin theory. Many new theories like synthetic theory, mutation theory are put forward.

Do you know?

Identical thoughts of Charles Darwin and Alfred Russel Wallace.



Alfred Russel Wallace

When Charles Darwin was formulating the theory of evolution in his mind, he received a letter with an article sent by Alfred Russel Wallace about his studies in the Indonesian island. The article was about Natural selection. Darwin was surprised about same theory in his mind. Later in the same year Charles Darwin and Alfred Wallace jointly published an article in the 'Journal of Linnaean Society' about natural selection. It was only after this Darwin published his famous book, "The origin of Species" in 1859. However their thoughts gained criticism at that time because they did not explain how variations are inherited. After the discovery of mitosis and meiosis it was understood properly.

Speciation

How new species are evolved?

We have seen variations in a population of species, where the organism contain the traits that helped to adapt to the environment. These organisms are going to survive more efficiently. But in the same population the organism which contains the non benificial traits may not be adapted in the environment. They are going to perish or eliminated slowly, like red and blue beetles in a population which we have discussed earlier in this chapter. These small changes within the species for example colour of beetles red and green is known as micro evolution.

Now we are going to discuss how new species are formed. This is known as speciation, which is also known as Macroevolution.

We have seen red and green beetles can mate each other and can have offsprings. But let us imagine that red and green beetles are separated by some cause (for example while eating beetles crows dropped some beetles accidently in the long distance far away places) for long years. There might be a lot of variations taken place in these years in the red and green beetle population. Now even though they may meet accidentally, they cannot mate and produce new offsprings. They can only mate in their population either red or green and can reproduce its off spring. Thus new species have been formed.

Evidences of evolution

How does the evolution of organisms taken place? Whatever scientists propose they require evidences or proofs. In the same way evolution of organisms requires evidences. Let us examine some of them.

Homologous and analogous organs

When we try to understand evolutionary relationships, we identify that some traits have common ancestors. These traits in different organisms would be similar because they are inherited from a common ancestor. You may be surprise to know that the internal structure of forelimb of a whale (swimmer) wing of a bat (flyer), leg of a cheetah (runner), claw of a mole (digger) and hand of a man (grasping). If we carefully observe the anatomy of all these animals, they show a common pattern in the arrangement of bones, even though their external form and functions are different. It indicates that all the vertebrates have evolved from a common ancestor and these organs are called homologous organs. This type of evolution is called divergent evolution.

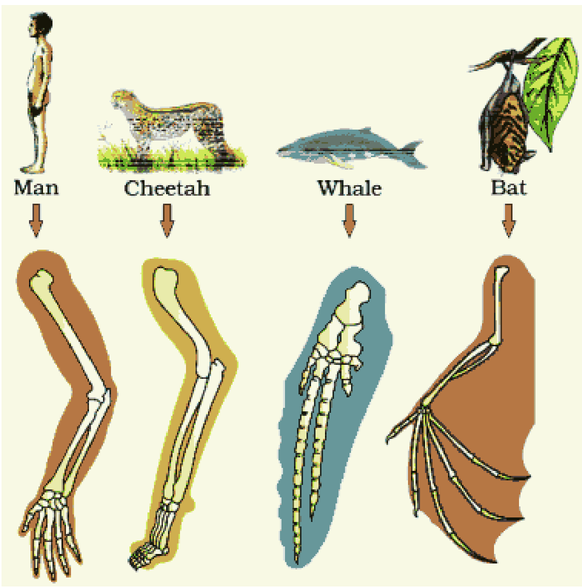


fig-13: Homologus organs

However, all similarities simply in organ shape are not necessarily to have a common ancestry. What would we think about the wings of birds and bats, for example (fig-). Birds and bats have wings, but squirrels and lizards do not. So birds and bats are more closely related to each other than squirrels or lizards.

Before we jump into this conclusion, let us look at the wings of birds and bats more closely. When we observe, we find that the wings of bats have skin folds (patagium) stretched between elongated fingers. But the wings of birds have a feathery covering all along the arm. The designs of the two wings, their structure and components are different. They look similar because they have a common use for flying, but their origin is not common. This gives the 'analogous' characteristics (Traits). As the above mentioned organs which are structurally different but functionally similar are known as 'Analogous organs'. This type of evolution is called convergent evolution.

Evidences from embryology

Activity-5

Let us observe different stages of development of vertebrate embryos. Try to find out similarities and differences and discuss with your friends.

fig-14: Embryological evidences

Embryology is the study of the development of an organism from egg to adult stage. Tadpole of a frog resembles fish more than the frog. What does this indicates? Does it indicate that frogs have evolved from ancestors of fish?

There are remarkable similarities in the embryos of different animals from fish to man. The resemblance is so close that at an early stage even an experienced embryologist would find difficulty to distinguish one embryo from the other. What does it indicate? Does it indicate that life history of every individual, exhibits the structural features of their ancestors? This strengthens the view of the existence of a common ancestor from which all these have evolved.

Evidences from fossils

We know some species which existed million years ago, but we may not find them now. They might be extinct and some of them may be found in the form of fossils. For example we know Dinosaurs the biggest animal on land which were present long time ago but now they are extinct. The scientists got evidences of presence of Dinosaurs like animals in the form of fossils.

What are fossils?


fig-15: Fossil

Fossils are evidences of ancient life forms or ancient habitats which have been preserved by natural processes. Fossil evidence is typically preserved within the sediments deposited beneath water and land. They can be actual remains of once lived such as bones or seeds or even traces of past event such as dinosarus foot print or ripple marks on a pre-historic shore. Usually when organisms die, their bodies will be decomposed and lost. Sometimes the body or some parts of the body do not decompose completely. For example if a dead insect get caught in mud, it will not decompose quickly and the mud will eventually harden and retain the impression of the body parts of insect. All such preserved traces of living organisms are called fossils.

Geologists can tell the age of a fossil. The study of fossil is called **'Palaeontology'.** Palaeontologists determine the age of fossil by using carbon dating method. The breakdown of radioactive isotopes of certain elements such as Carbon, Uranium and Potassium takes place at a known rate. So the age of rock or mineral containing isotopes can be calculated.


fig-16: Dinosarus

- Collect information about carbon dating method and radioactive isotopes and discuss with your teacher or from library display your collections in your class.

A rare and magnificient fossil of the dinosaurs, ketosaurs belonging to the lower Jurassic age going back to about 160 million years were collected from Yamanapalli in Adilabad district of Andhra Pradesh. This fossil has 14 metres length and 5 metres height. This fossil is preserved at BM Birla Science Centre in Hyderabad.

Do you know?

See the picture of Archeopteryx. Does it resemble a bird? Or a reptile? Or both? The organisms which bear the characters of two different groups are called connecting links. Archeopteryx has some avian characters and some reptelian characters. Hence it is recognised as connecting link between aves and reptiles.


Archeopteryx

Human evolution

Human evolution is the evolutionary process leading up to the appearance of a modern human being. We the present human beings are also have an evolutionary history like plant and other animals. Early man like forms appeared about 7 lakhs 50 thousand years ago. The first sure fossil of our own species of man the Homosapiens, indicate that true man appeared on the earth 2 lakhs 50 thousand years ago.

Evolution of man through ages:

Homo habilus lived between 1.6 - 2.5 million years ago.

Homo erectus lived between 1 - 1.8 million years ago.

Homo sapiens neanderthalensis lived between 2,30,000 - 3,00,000 thousands years ago.

Homo sapiens (present man) appeared about 40 thousand years ago.

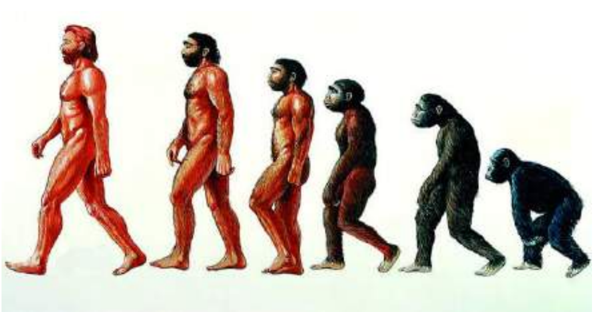


fig-17: Human evolution

There is a great diversity in human forms and features across the planet. So that for a long time, people used to talk about human 'races'. Skin colour used to be the commonest way of identifying the so called races. Some were called black, some white or brown. A major question debated for long time was, have these apparent groups evolved differently? Over recent years, the evidence has become very clear. The answer is that there is no biological basis to the notion of human races. All humans are a single species with a common ancestor.

Not only that, regardless of where we have lived for the past few thousand years, we all come from Africa. The earliest members of the human species, Homo sapiens, can be traced there. Our genetic footprints can be traced back to our African roots. A couple of hundred thousand years ago, some of our ancestors left Africa while others stayed on, while the residents spread across Africa. The migrants slowly spread across the planet –from Africa to west Asia, Then to Central Asia, Eurasia, South Asia, East Asia. They travelled down the island of Indonesia and the Philippines to Australia, and they crossed the Bering land bridge to the Americas. They did not go in a single line, so were not travelling for the sake of travelling, obviously. They went forwards and backwards, with groups sometimes separating from each other, even moving in and out of Africa. Like all other species on planet, they had come into being as an accident of evolution, and were trying to live their lives the best they could.

Human being - a moving museum

During the course of evolution some organs remain in the organisms. You have studied about appendix in the digestive system. In human beings it has no role to play in the process of digestion. But in herbivores like rabbit appendix plays an important role. Such type of organs which are not useful in animal are called vestigial organs.

- *Think why did ancient human beings traveled from one place to other and how did they traveled?*

There are nearly 180 vestigial organs in human beings. For example pinna, hair on skin, mammary glands in human, etc. That's why human being is said to be a moving museum of vestigial organs.

Key words

Variations, offsprings, traits, phenotype, genotype, heterozygous, homozygous, independent assortment, allele, heredity, autosomes, allosomes, natural selection, analogous organs, embryological evidences, Human evolution.

What we have learnt

- Variations are quite apparent among closely related groups of organisms.
- In about 1857 Gregor Johann Mendel started working on the problem of how variations were passed from one generation to other.
- Mendel had choosen seven distinguishing traits: flower colour, position, seed colour, shape, pod colour, pod shape, stem length.
- In monohybrid experiment F1 generation all pea seeds were yellow.
- In F2 generation about 75% seeds were yellow and about 25% seeds were green. This is called phenotype and the ratio is 3:1.
- In F2 generation out of 75%, 25% were pure yellow seeds 50% were yellow seeds but green as a recessive factor. Remaining 25% were pure green. This is called genotype and the ratio 1:2:1.
- Every pea plant has two 'factors' which are responsible for producing a particular property or trait called allele.
- The factors for each pair of characters assorts independently of the other pairs. This is known as "Law of independent assortment".
- Crossing yellow and green seeds produced all yellow seeds. Because yellow is dominant factor.
- Each parent passes randomly selected copy (allele) of only one of these to its offspring.
- The process of acquiring characters or traits from parents is called 'Heredity'.
- Each human cell contains 23 pairs of chromosomes. Out of these 22 pairs are called autosomes and one pair is called allosomes.

- Lamarck proposed that the acquired characters are passed to the offspring in the next generation.
- Each species tend to produce large number of offsprings, but only the fittest can survive.
- Homologous, analogous organs and embryological evidences explain evolutionary relationships.
- Some traits in different organisms would be similar because they are inherited from a common ancestor.
- Fossils are evidences of ancient life forms or ancient habitats which have been preserved by natural processes.

Improve your learning

1. What are variations? How do they help organisms?(AS1)
2. One student (researcher) wants to cross pure tall plant (TT) with pure dwarf (tt) plant, what would be the F1 and F2 generations? Explain.(AS1)
3. One experimenter cut the tails of parent rats , what could be the the traits in offsprings? Do the daughter rats contain tails or not? Explain your argument.(AS1)
4. In a mango garden a farmer saw one mango tree with full of mango fruits but with a lot of pests. he also saw another mango tree without pests but with few mangoes. But the farmer wants the mango tree with full of mango fruits and pest free. Is it possible to create new mango tree which the farmer wants? Can you explain how it is possible?(AS1)
5. Explain monohybrid experiment with an example, which law of inheritance can we understand? Explain.(AS1)
6. What is the law of independent assortment? Explain with an example?(AS1)
7. How sex determination takes place in human? Explain with example.(AS1)
8. Explain the Darwin's theory of evolution 'Natural selection' with an example?(AS1)
9. What are variations? Explain with a suitable example.(AS1)
10. What variations generally have you observed in the species of cow?(AS1)
11. What are the characters Mendel selected for his experiments on pea plant?(AS1)
12. In what way Mendel used the word 'Traits'- explain with an example.(AS1)
13. What differences Mendel identified between parent and F_2 generation.(AS1)
14. Male is responsible for sex determination of baby – do you agree? If so write your answer with a flow chart.(AS1)
15. Write a brief note on analogous organs.(AS1)
16. How do scientists utilise the information about fossils?(AS1)
17. Mendel selected a pea plant for his experiments. Mention the reasons in your point of view.(AS2)
18. If the theory of inheritance of acquired characters proposed by Lamark was true how will the world be?(AS2)
19. Collect information on the inherited traits in your family members and write a note on it.(AS4)
20. With the help of given information write your comment on evidences of evolution.(AS4)
    Mammals have four limbs as do birds, reptiles and amphibians. The basic structure of the limbs is similar, though it has been modified to perform different functions.
21. Collect information about carbon dating method. Discuss with your physical science teacher.(AS4)

22. Draw a checker board show the law of independent assortment with a flow chart and explain the ratio.(AS5)
23. Explain the process to understand monohybrid cross of Mendel experiment with a checker board.(AS5)
24. Prepare a chart showing evolution of man through ages.(AS5)
25. Nature selects only desirable characters. Prepare a cartoon.(AS6)
26. What is your understanding about survival of the fittest. Give some situations or examples that you observe in your surroundings?(AS7)
27. Write a monologue on evolution of a man to perform a stage show on the theatre day in your school.(AS7)

Fill in the blanks

1. The process of acquiring change is called ______________.
2. Mendel's experiment of stands for ______________.
3. The four characters observed in the experiments on law of independent assessment are __________.
4. If we cross pollinate red flower plant with white flower we will get ________ percent of mixed colour plants.
5. TT or YY, Tt or Yy are responsible for a _________________ character.
6. Female baby having 23 pairs of autosomes at the age of 18 years she has __________ pair autosomes and _______ of sex chromosomes.
7. The population grows in ________________ progression where as food sources grow in _______________ progression.
8. A goat which walks properly can't live for a long time. According to Darwin this represents _______________.
9. Forelimb of whale is for swimming where as in horse it is used for _______________.
10. The study of fossils is called _______________.

Choose the correct answer

11. Which of the following is not a variation in rose plant. ( )
    a) Coloured petals b) Spines c) Tendrils d) Leaf margin
12. According to Mendel alleles have the following of a character. ( )
    a) Pair of genes b) Responsible for character
    c) production of Gametes d) Recessive factors
13. Natural selection means ( )
    a) Nature selects desirable characters b) Nature rejects undesirable characters
    c) Nature reacts with an organism d) a, b
14. Palaeontologists deal with ( )
    a) Embryological evidences b) Fossil evidences
    c) Vestigial organ evidences d) all

Annexure-I

Mendel's laws of independent assortment

Till now we have discussed about the Mendel's hypothesis with monohybrid cross. Mendel's also tried to understand the inheritance of two pairs of characters together. In this dihybrid cross, parents produce offsprings containing the factors for Characters (traits) of Yellow (YY), Round (RR), and wrinkled (rr), green (yy). These characters appeared independently without mixing with each other in F2 generation, which were produced by self pollination in F1 generation.

♀ \ ♂	R Y	R y	r y	r Y
R Y	RR YY	RR Yy	Rr Yy	Rr Yy
R y	RR Yy	RR yy	Rr yy	Rr Yy
r y	Rr Yy	Rr yy	rr yy	rr Yy
r Y	Rr YY	Rr Yy	rr Yy	rr YY

9 :3 :3 :1

Round yellow · Wrinkled, yellow · Round, green · Wrinkled, green

Observe thc checker board given here carefully and note down different combinations of characters resulted from dihybrid cross.

1. RRYY, 2. RRYy, 3. RrYY, 4. RrYy, 5. RRYy, 6. RrYY, 7. RrYy, 8. RrYy, 9. RrYy are having Round and Yellow seeds.

1. RRyy, 2. Rryy, 3. Rryy have Round and Green seeds

1. Rryy, 2. rrYy, 3. rrYy have Wrinkled and Yellow seeds

1. rryy have Wrinkled and Green seeds

From the above results it can be concluded that the factors for each character or trait remain independent and maintain their identity in the gametes. The factors are independent to each other and passes to the offsprings (through gametes).

In the inheritance of more than one pair of characters (traits), the factors for each pair of characters assorted independently of the other pair. This is known as **"Law of independent assortment".**

Mendel believed that every character or trait is controlled or responsible by a pair of factors. The factors which are responsible for a character or trait of an organism, now named as 'genes'. The pair of genes which are responsible for a character are called as 'alleles'. Alleles are of two types one is homozygous type (YY or TT) and the other is heterozygous (Yy or Tt).