CHAPTER 9

Heredity and Evolution

EXAM DRILL

ANSWERS

1. **(c) :** The main features of Darwin's Theory of Natural Selection are - over production or rapid multiplication (all organisms possess enormous fertility), struggle for existence (struggle between the individuals of same species as well as different species and against the environmental factors) and origin of species. Environmental effect theory is given by Lamarck.

OR

(d) : Test cross is of two types : monohybrid (phenotypic ratio 1 : 1) and dihybrid (phenotypic ratio 1 : 1 : 1 : 1).

2. **(d) :** According to Darwin's theory, various salient features are:

(i) Over production
(ii) Limited food and space
(iii) Struggle for existence
(iv) Survival of the fittest, etc.

3. **(a)**

4. **(d) :** Ernst Haeckel states that ontogeny repeats phylogeny. In other words, an organism repeats its ancestral history during its development.

5. **(d) :** Phenotype is the observable or measurable characteristics that may be visible to eye (*e.g.*, height of a plant, colour of flower, etc.).

OR

(d) : Pea plants used by Mendel for his experiments had 7 pairs of contrasting characters.

6. **(c)**

7. **(b) :** According to the studies of anthropologists, it has been revealed that human evolution started in Africa.

8(i) X is instantaneous speciation whereas Y is gradual speciation.

8(ii) Darwin's finches are example of allopatric speciation which is a types of gradual speciation.

8(iii) **(b)**

8(iv) **(a) :** Insantaneous or abrupt speciation operates through individuals and leads to sudden development of new species. It mainly occurs through mutations. The mutation may involve the changes in one or more nucleotide pairs of a gene, or one or more gene of a chromosome, or one or more chromosomes of germ cells of an individual. The species produced by these mutations are morphologically similar but reproductively isolated. For example, the mutation produce a short-legged sheep variety Ancon sheep from a long-legged parents in a single generation.

9(i) P is homologous organ, Q is analogous organ and R is vestigial organ.

9(ii) The analogous organs indicate the convergent evolution. The analogous organs are different in their basic structure and developmental origin but they appear similar and perform similar functions.

9(iii) **(d)**

9(iv) **(d) :** Organ R is vestigial organs. Vestigial organs are believed to be remnants of organs which were complete and functional in their ancestors. *E.g.*, vermiform appendix, nictitating membrane, wisdom teeth, coccygeal vertebra, etc.

10. Human sperm has 22 autosomes.

OR

Genetic drift is defined as the random changes in gene frequency in small isolated populations owing to factors other than natural selection.

11.

Parents :			TtRr			×		ttrr		
			↓					↓		
Gametes :	TR	Tr	tR	tr				tr		
F_1 :	TtRr		Ttrr		ttRr			ttrr		
	1	:	1	:	1	:		1		

Genotype of tall, red-flowered plant is TtRr.

12. When male produces two types of gametes, *i.e.*, 50% with X and 50% with Y, it is called male heterogamy. It is shown by human beings, *Drosophila*, etc.

13. **(c) :** In mammals, the presence of a Y chromosome is required for the development of a male sex phenotype. Y chromosome is required for maleness, moreover, the presence of a single Y chromosome is sufficient even in the presence of several X chromosomes (*e.g.*, XXXY).

14. **(a) :** Appearance of newer forms of organisms from pre- existing organisms through modification is called evolution. New organisms did not develop suddenly. They were produced by modification of the older forms through mutation, long term adaptation, speciation and natural selection.

15. Basic features of inheritance are:

(i) Characters are controlled by genes and each gene controls one character.

(ii) Chromosomes are gene bearers and genes are basic unit of heredity.

(iii) One form of allele may be dominant on other, *i.e.*, genes are allelic in nature.

(iv) The two forms of alleles, separate at the time of gamete formation, *i.e.*, they do not mix with each other.

(v) Two allelic forms of a gene are brought together in zygote.

16. Differences between somatogenic and blastogenic variations are :

S.No.	Characters	Somatogenic variations	Blastogenic variations
(i)	Nature of cells involved	Only somatic cells.	Germ cells of the gonads.
(ii)	Period of origin	During an individual's life span, so called acquired traits.	During gametogenesis and fertilisation, so called inherited traits.
(iii)	Role in heredity	Non-inheritable, thus have no role in evolution.	Inheritable, so play important role in evolution.
(iv)	Examples	Better developed muscles in an athlete.	Polydactyly and sickle cell anaemia.

17. (i) The evolutionary trend that gave rise to new species of organisms to make them suitable for the new habitats and new way of life is called adaptive radiation.

(ii) The evolution that brought about similar kind of changes or adaptations in the organisms living in different regions, having similar habitats is called adaptive convergence or convergent evolution.

18. (i) 25 per cent of plants are with wrinkled seeds in F_2 generation.

(ii) 50 per cent of plants are hybrid plants (heterozygous), as they contain the genes for both round seed and wrinkled seed.

(iii) Punnett square for the above experiment.

Parents : RR (Round seed) × rr (Wrinkled seeds)

Gametes : R, r

F_1 : Rr (Round)

Selfing : Rr × Rr

F_2 :

♀ \ ♂	R	r
R	RR Round	Rr Round
r	Rr Round	rr Wrinkled

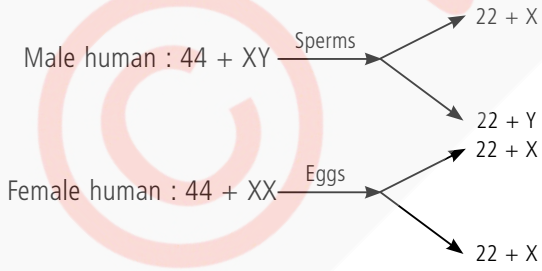
OR

Random change in the gene frequency of small population occurring by chance irrespective of its being beneficial or harmful is called genetic drift. Consider that in a small group of red-coloured beetles, a few beetles mutate, develop the inheritable colour variation and become blue coloured. But such blue-coloured beetles do not have any survival advantage over red beetles, since both of them are easily spotted by the crows which eat both types of beetles. Such beetle population remains dominated by red coloured beetles. In such a population, if by chance, most of red-coloured beetles are crushed and killed under the feet of an elephant and most of blue coloured beetles survive, then beetle population will be dominated by blue-coloured beetles which gradually increases their number by sexual reproduction. But such a change is not possible in large population because no elephant could cause such major havoc in the large beetle population.

These examples show that the frequency of useful genetic variabilities increase over generation. Natural selection is the phenomenon wherein nature selects organism having traits favourable to environment. Thus, natural selection and genetic drift work towards evolution.

19. Reproductive isolation is the prevention of interbreeding between populations of two different species. Natural selection may also operate simultaneously in a different way in these geographically isolated sub-populations. For example in one geographical region crows are killed by eagles whereas in the other geographical region, crows continue to increase in number. In such situation green body colour variants of beetle will not be selected at the first geographical region whereas these variants will be selected at the other geographical site. In this way both genetic drift and natural selection make these geographically isolated sub-populations to become more and more different from each other. After many years when the organisms from these two populations meet they are incapable of reproducing with each other. This phenomenon is called reproductive isolation. Thus, reproductive isolation alongwith genetic variation and natural selection are essential for the formation of new species or speciation.

20. Human beings have 22 pairs of autosomes and one pair of sex chromosomes. Women bear XX type of sex chromosomes and men are with XY type of sex chromosomes. Thus, men are with 44 + XY combination and women are with 44 + XX combination of chromosomes. Hence,

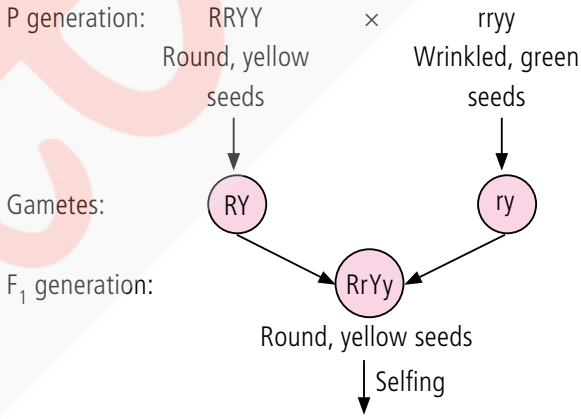


It is just the chance, if sperm 22 + X fuses with egg 22 + X, progeny will be a girl (44 + XX) but if by chance sperm 22 + Y fuses with egg 22 + X; then progeny will be a boy (44 + XY).

21. The environment does not remain constant. It is ever changing. Thus, the organisms should also adapt themselves to the changing environmental conditions. Therefore, the organisms of a species undergo some modifications (variations) in their colour, form, structure and functioning. To explain the phenomenon of survival of the fittest, the extinct reptiles can be cited as an example. During the evolution of reptiles, giant reptiles, the dinosaurs, etc., appeared. Majority of them were herbivores, but due to certain climatic changes, the vegetation disappeared and, therefore, most of them became extinct. However, small animals who could change their feeding habits from herbivorous to carnivorous diet survived, because they could easily get adapted to the changed environment. These, therefore, would survive more and hence were selected by nature.

OR

In a dihybrid cross given by Mendel, it was observed that when two pairs of traits or characters were considered, each trait expressed independent of the other. Thus, Mendel was able to propose the Law of Independent Assortment, which says that pair of genes separate independently of each other during gamete formation. This could be explained clearly from the given cross:



	RY	Ry	rY	ry
RY	RRYY Round yellow	RRYy Round yellow	RrYY Round yellow	RrYy Round yellow
Ry	RRYy Round yellow	RRyy Round green	RrYy Round yellow	Rryy Round green
rY	RrYY Round yellow	RrYy Round yellow	rrYY Wrinkled yellow	rrYy Wrinkled yellow
ry	RrYy Round yellow	Rryy Round green	rrYy Wrinkled yellow	rryy Wrinkled green

F_2 generation ratio : 9 (Round-yellow) : 3 (Round-green) : 3 (Wrinkled-yellow) : 1 (Wrinkled-green)

22. Differences between homologous and analogous organs are:

S.No.	Homologous organs	Analogous organs
(i)	The different organs in the different organisms may have similar basic anatomical structure even though they have different morphology and different functions.	Some organs have totally different structural organisation in different organisms, but perform similar functions in various organisms. Such organs are called analogous organs due to the analogy in function.
(ii)	This indicates that these organs must have evolved from a common ancestry which in course of time developed into organs with different structural features adopted to the respective environments. This is called divergent evolution.	The evolution giving rise to this kind of analogy is called convergent evolution.
(iii)	Examples : Forelimbs of man, cheetah, whale and bat, Thorn of *Bougainvillea* and tendril of cucurbita.	Examples : Wings of insect and bat, fin of shark and flippers of dolphin.

23. Evolution should not be equated with "progress" because of following reasons:

(i) In evolution, older species are not eliminated during the formation of new species and most of older and simpler species still survive, *e.g.*, earliest organisms like bacteria are found even in many inhospitable habitats like hot springs, deep-sea thermal vents, Antarctic ice, etc. Human beings are the climax species but simply another species in the evolutionary process of organisms.

(ii) The evolved species are not always better than the parental species. Evolution depends upon natural selection and genetic drift which together result in a population which is reproductively isolated from the parental species.

24. Differences between Lamarckism and Darwinism are :

S.No.	Lamarckism	Darwinism
(i)	This theory states that there is an internal vital force in all organisms.	It does not believe in the internal vital force.
(ii)	Lamarckism considers new needs or desires produce new structures and change habits of the organisms.	They do not form part of Darwin's natural selection theory.
(iii)	According to this theory if an organ is constantly used it would be better developed whereas disuse of organ results in its degeneration.	An organ can develop further or degenerate only due to continuous variations.
(iv)	It does not consider struggle for existence.	Struggle for existence is very important in this theory.
(v)	All the acquired characters are inherited to the next generation.	Only useful variations are transferred to the next generation.
(vi)	Lamarckism does not believe in survival of the fittest.	Darwin's natural selection theory is based on survival of the fittest.

OR

Molecular phylogeny is the phenomenon of determining evolutionary relationship between the organisms by determining degree of differences in their biomolecules like DNA, proteins, etc. It can be understood through following examples:

(i) Similar enzymes of different organisms are similar in their chemical nature and mode of action.

(ii) Similar hormones of different vertebrates are similar in their chemical nature, target organs and mode of action.

(iii) The components of body fluids like blood and lymph and their functions are nearly similar in different vertebrates.

(iv) Blood proteins precipitation tests confirm not only similarity but also degree of evolutionary and serological relationship between different vertebrates. These tests have revealed that man is most similar to ape like gorilla and chimpanzee, next similar to old world monkeys followed by new world monkeys and tarsiers.

25. Mendel performed experiments on pea plants for several years and based on his observation, he formulated three principles/laws of heredity, which are as follows:

(i) Principle of dominance : In a hybrid or heterozygous individual two dissimilar unit factors are present for one character. Out of two factors (genes) only one is able to express itself and it prevents expression of the other. The one which expressed itself is called dominant gene or factor and the one which remains unexpressed is called recessive factor or gene. For example, in hybrid tall (Tt) only unit factor (gene) of tallness expresses itself, hence it is called dominant. The unit factor (gene) for dwarfness fails to express itself, hence it is called recessive.

(ii) Principle of segregation : The two unit factors of a character which remain together in an individual do not get mixed up, or get contaminated and keep their distinct identity. They separate or segregate during gamete formation so that each gamete receives only one factor (gene) for each character and is always pure. This principle is also called principle of purity of gametes. For example, in a hybrid tall pea plant, unit factors of tallness (T) and dwarfness (t) separate out or segregate out during gamete formation. The two unit factors occur with equal frequency in male and female gametes.

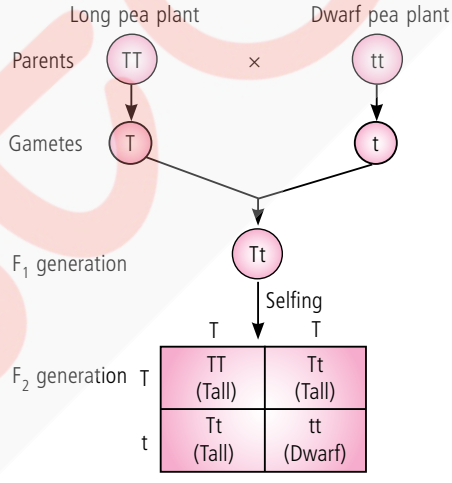
(iii) Principle of independent assortment : This principle states that the unit factor of each character is assorted or distributed into the gametes independently of the unit factors (genes) of any other character and gets randomly rearranged in the offspring. For example, in Mendel's dihybrid cross, the offspring of F_1 generation on self breeding produced four types of offspring. Two types were similar to parents while the remaining two types had combination of traits. This became possible because the unit factors of the two characters assorted independent to each other.

OR

The crosses which were made to study the inheritance of one pair of contrasting characters by Mendel are known as monohybrid crosses. For example in one such cross Mendel selected two sets of pea plants with contrasting characters for height. One set of pea plants was above six feet in height and the other set was of short plants with an average height of one foot. Mendel called these plants homozygous tall and homozygous dwarf. These were called as pure strain.

Mendel cross pollinated homozygous tall plants with homozygous dwarf plants. These plants represented the parent generation (P generation).

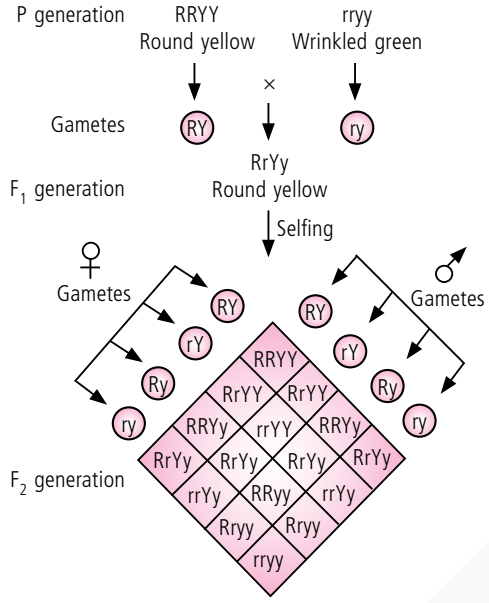
The plants grown from the seeds of parental plants were hybrid plants, these belonged to the F_1 generation or first filial generation. All plants of F_1 generation were tall. When plants of F_1 generation were self pollinated, seeds produced in next generation in the following ratio:



Phenotypic ratio : 3 : 1

The crosses which were made to study the inheritance of two pairs of contrasting characters simultaneously are referred as dihybrid crosses. For example, in one such cross Mendel selected pure breeding plants for (i) yellow and green colour of seeds, (ii) round and wrinkled shape of the seeds. He cross-pollinated flowers of the plants which were developed from homozygous round shape and yellow coloured seeds with flowers of plants raised from homozygous wrinkled shape and green coloured seeds. The plants of this generation were referred as P generation or parent generation. The seeds produced as a result of cross-pollination of P generation plants belonged to F_1 generation or first filial generation. All the seeds produced in this generation were yellow and round. Plants raised from these F_1 seeds belonged to F_2 generation. Plants of F_1 generation were self-pollinated. On self-pollination these produced different seeds in next

generation (F_2 generation or second filial generation) in the following ratio:



Yellow and round : 9, yellow and wrinkled : 3, Green and round : 3, Green and wrinkled : 1

26. Homologous organs are those structures which are different in appearance and perform different functions but have similar basic structure and developmental origin, this relationship is called homology or divergent evolution, *e.g.*, forelimbs of vertebrates like seal, bird, bat, horse, man, etc., look different and perform different functions but are built on the same pentadactyl (5-digited) plan and have similar arrangement of bones, muscles, blood vessels, etc., although these are modified differently due to adaptations to perform their specific function. Other examples of homologous organs are: Potato tuber and runners of grasses (both are modified stems); human teeth and tusks of elephant, etc.

Presence of homologous organs confirm common ancestry and evolutionary relationship.

Analogous organs are those structures which are different in their basic structure and developmental origin but appear similar and perform similar function while this relationship is called convergent evolution or analogy, *e.g.*, wing of an insect and a bird both of which are flat structures and help in flying but are different in their origin. The insect wing is modified integumentary (skin) structure while a bird's wing is a modified forelimb. It shows that all the similarities are not necessarily because of common ancestry. This analogy in these organs is due to similar adaptations to perform similar function rather than their common ancestry.

27. Evolutionary history of man has been built from the fields of palaeontology (fossil studies) and molecular biology (especially DNA changes). The scientific study of tracing of human evolution is called anthropology. Scientists involved in studying human evolution are called anthropologists. Studies have revealed that human evolution started in Africa and earliest human type was *Australopithecus africanus* (African ape man). It has been dated back about 5 million years ago. It had many ape-like characters but had bipedal locomotion like man. Some of these ancestral types spread across Africa while some of them slowly migrated to West Asia, then to Central Asia, Eurasia, South Asia, East Asia, islands of Indonesia, Australia and America along different evolutionary lines. These first human types evolved into modern man, *Homo sapiens*, through a number of intermediate human types: *Homo erectus erectus* (Java man), *Homo erectus pekinensis* (Peking man), *Homo sapiens neanderthalensis* (Neanderthal man), *Homo sapiens fossilis* (Cro-Magnon man).

In the course of their evolution, these migrant human types went forwards and backwards, sometimes separated and sometimes mixed with each other, and moved in and out of Africa. Modern man evolved from Cro-Magnon man about 25,000 years ago and spread all over the world about 10,000 years ago.

Modern man is divided into four ethnic groups: Negroid (African pygmies and bushman); Caucasian (Italian, English); Eastern (Chinese, Japanese, Eskimos, etc). and Mongoloid. These ethnic groups differ from one another in their skin colouration, lips, hair pattern, etc., but all of these belong to same species because these are not reproductively isolated from one another. All human races have same chromosome number and similar gross morphology of chromosomes.

28. Origin of new species from the existing one due to reproductive isolation of a part of its population is called speciation. On the basis of period taken in speciation, there are two types of mechanisms of speciation:

(i) Gradual speciation : It is the gradual divergence of populations due to accumulation of variations over a

long period of time. It operates through sub-populations. It is again of two types: Allopatric speciation and Sympatric speciation.

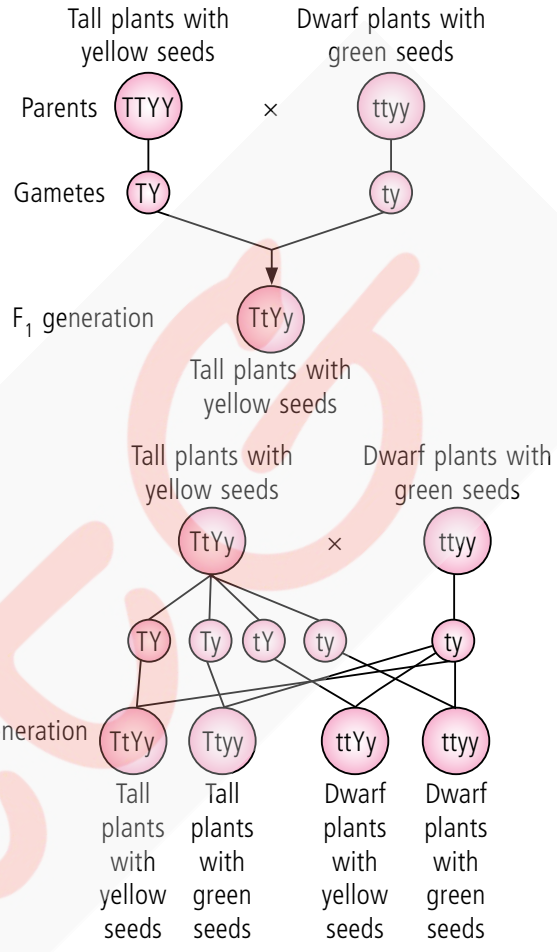
(a) Allopatric speciation occurs when an original population becomes separated into two or more sub-populations due to development of certain geographical barriers which impose the restrictions on the gene flow between these sub-populations and they become reproductively isolated. The geographical barriers include a creeping glacier or an ocean or a mountain range or a big desert. Geographical isolation may also be achieved by migration of some individuals to a new area which is geographically isolated from original range. These sub-populations become more and more different due to processes of genetic drift and natural selection which operate differently in these different geographical areas. Finally, such sub-populations become reproductively isolated and become different species, called allopatric or geographical species. For example, Darwin's finches (A group of passerine birds discovered by Darwin on Galapagos islands) are geographically and reproductively isolated from related birds of South American mainland.

(b) Sympatric speciation : It occurs within same geographical area and within original population. But the sub-population become reproductively isolated by ecological barriers (having different habitats) or ethological barriers (different breeding behaviours). Example (i) Pig frog and Gopher frog occur in different habitats in same pond so are reproductively isolated from each other and are different species.

(ii) Instantaneous or Abrupt speciation: It is the sudden development of new species and operates through individuals so is not a populational phenomenon. It mainly occurs through

sudden, large and inheritable changes in the genetic material (DNA), called mutations. Individuals with mutations are called mutants. The changes in genetic material may involve one or more nucleotide pairs of a gene, or one or more genes of a chromosome, or one or more chromosomes of germ cells of an individual. Such mutations can produce sibling species which are morphologically similar but reproductively isolated. Example (i) Appearance of a short-legged sheep variety called Ancon sheep from long-legged parents in a single generation.

29. The phetotypic ratio obtained will be 1 : 1 : 1 : 1. It can be explained by the following cross:



Phenotypic ratio : 1 : 1 : 1 : 1

Genotypic ratio : 1 : 1 : 1 : 1

OR

(i) Artificial selection is the process by which man selects trait(s) useful to him for improving the qualities of domesticated plants and animals.

Man selects the individuals having the desired traits and separates them from those which do not possess such characters. The selected individuals are interbred. This process of artificial selection, when repeated for many generations, produces a new breed with desired traits. In this way, wild forms are modified through artificial selection. ***E.g.,*** plant breeders have produced several useful plants like wheat, rice, sugarcane, cotton, pulses, vegetables and ornamental plants by artificial selection. Several crop plants like broccoli, kohlrabi, cabbage, cauliflower, a leafy vegetable called kale, etc., are formed from a common wild cabbage species by selective breeding.

(ii) Vestigial organs are not functional in the present day organisms, but were functional and fully developed in related ancestral forms. They have lost their functions and have reduced due to changed conditions in due course of evolution. These organs are not required in present environmental conditions, but definitely these organs show close kinship of present organisms and their ancestral forms. Some of the vestigial organs in human beings are vermiform appendix, muscles of external ear, nictitating membrane, coccygeal (tail) vertebra, wisdom teeth (third pair of molars), hair on body, etc. The presence of vestigial organs in humans give an idea about the evolution of human beings.

30. Variations are the structural, functional or behavioural changes from the normal characters developed in the living organisms. Origin and accumulation of variations are must because these provide raw material for evolution. These may be inheritable or non-inheritable. Inheritable variations participate in evolution, while non-inheritable variations do not participate in evolution.

There are two types of variations:

(i) Somatogenic variations

(ii) Germinal variations

The somatic variations are non-germinal. These are acquired during life time of an individual. These are a result of environmental factors like changes in light, temperature, food availability, etc. The somatic variations are non heritable therefore, do not play any role in evolution, *e.g.*, beetles feed on the leaves of bushy plants. Due to a plant disease, the leaves of the bushes start falling which cause a reduced supply of food material and under-nourishment of the beetles. This result in the decrease in average weight of adult beetles. This would continue for several generations after which, somehow the plants recover from the disease and show extensive growth of the leaves. Now, a lot of food material was available to the beetles and there was increase in average weight of adult beetles. So, reduction of weight of beetles was a temporary phenomenon and had no evolutionary significance.

The germinal variation occurs at the time of formation of gametes in the reproductive organ. These are developed either due to mutations or recombination of genes. These are inheritable so are transmitted from one generation to another and these play an important role in evolution, *e.g.*, Polydactyly (extra fingers) in man and sickle cell anaemia.

OR

In human beings, the sex of the individual is genetically determined. In other words, the genes inherited from the parents decide the sex of the offspring. In diploid (2N) organisms with separate sexes, a specific pair of chromosomes determine the sex of the individual. They are called sex chromosomes. All other chromosomes are called autosomes. In case of autosomes, a pair of chromosomes are exactly similar as far as the shape and size are concerned, hence they are called homologous chromosomes. Sex chromosomes are heterologous, *i.e.*, different in shape and size. In human beings, 23 pairs of chromosomes are present in each cell. Out of 23 pairs, 22 pairs of chromosomes carry genes which control somatic traits, these are called autosomes. The 23rd pair of chromosomes determine the sex, hence these chromosomes are called sex chromosomes.

The human females have two X chromosomes (*i.e.*, XX) as sex chromosomes. Both the members of sex chromosomes are similar or homomorphic. However, human males have XY sex chromosomes, where X chromosome is morphologically distinct from Y chromosome. Y chromosome is smaller than X chromosome. Thus, they are dissimilar or heteromorphic.

During fertilisation there are equal chances that an ovum is fertilised by either a sperm having X chromosome or a sperm having Y chromosome. When a sperm carrying X chromosome fertilises an egg, the zygote develops into a female (XX condition). When a sperm carrying Y chromosome fertilises an egg, the zygote develops into a male (XY condition). Thus, the sex of a baby is determined at the time of fertilisation. The mechanism by which the sex of an individual is determined as it begins life, is called sex determination.

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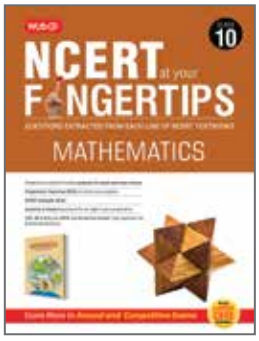

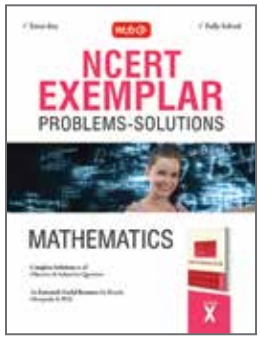

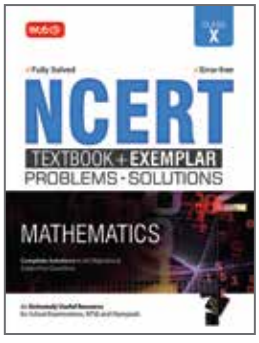

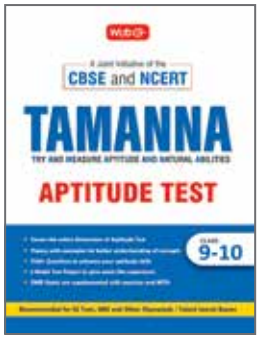

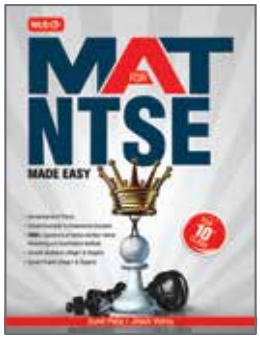

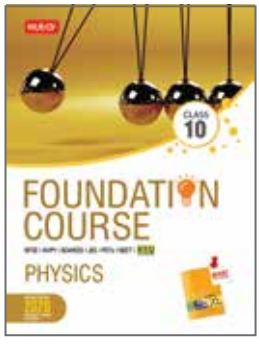

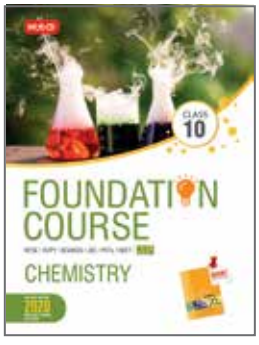

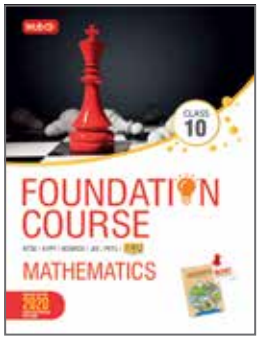

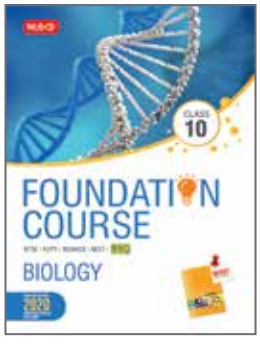

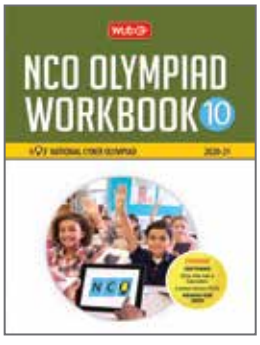

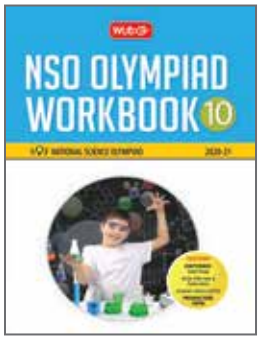

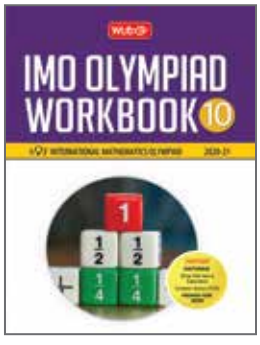

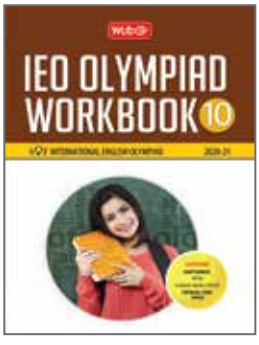

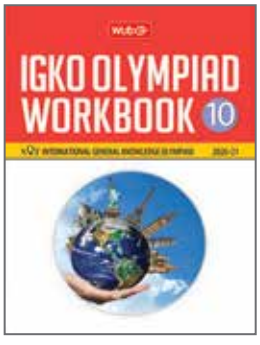

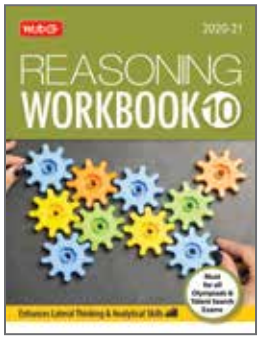

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