7
Evolution

Multiple Choice Questions (MCQs)

Q. 1 Which of the following is used as an atmospheric pollution indicator?

(a) Lepidoptera (b) Lichens (c) *Lycopersicon* (d) *Lycopodium*

Ans. ***(b)*** Lichens can be used as an atmospheric pollution indicator. They do not grow in areas that are polluted, as they are sensitive (especially phycobiont) to oxides of nitrogen and sulphur, hence unable to synthesise organic food and do not grow well.

Lepidoptera It is insect order.

Lycopersicon It is scientific name of tomato.

Lycopodium It is an pteridophyte.

Q. 2 The theory of spontaneous generation stated that

(a) life arose from living forms only

(b) life can arise from both living and non-living

(c) life can arise from non-living things only

(d) life arises spontaneously, neither from living nor from the non-living.

Ans. ***(c)*** The theory of spontaneous generation stated that life can arise from non-living things only. It is also known as abiogenesis.

Louis Pasteur by careful experimentation disapproved this theory and demonstrated that life arose from living forms (pre-existing life).

Q. 3 Animal husbandry and plant breeding programmes are the examples of

(a) reverse evolution (b) artificial selection

(c) mutation (d) natural selection

Ans. ***(b)*** *These are examples of artificial selection*

'Artificial selection' is a process in which the breeder choose to perpetuate only those forms that have certain desirable inheritable characteristics.

The other three options are incorrect as mutation is a sudden change in DNA sequence due to mutagenic agents such as chemicals and radiations.

Natural selection is a gradual process by which biological traits become either more or less common in a population as a function of the effect of the changing environment.

Reverse evolution or **devolution** is a notion that species can change into more primitive forms over time.

Q. 4 Palaeontological evidences for evolution refer to the

(a) development of embryo
(b) homologous organs
(c) fossils
(d) analogous organs

Ans. ***(c)*** Palaeontological evidences for evolution refer to the evidences from fossils. Fossils are the preserved remains or traces of organisms from the distant past. The study of fossils is called Palaeontology. The other options are not correct because the development patterns of embryo refer to embryological evidences for evolution.

Homologous and analogous organs provide evidences for comparative anatomy and morphology.

Q. 5 The bones of forelimbs of whale, bat, cheetah and man are similar in structure, because

(a) one organism has given rise to another
(b) they share a common ancestor
(c) they perform the same function
(d) the have biochemical similarities

Ans. ***(b)*** The bones of forelimbs of whale, bat, cheetah and man are similar in structure, because they have a common ancestor.

These are homologous organs which have different functions across diverse forms, but are developed along same pattern. These organs arise due to divergent evolution.

Q. 6 Analogous organs arise due to

(a) divergent evolution
(b) artificial selection
(c) genetic drift
(d) convergent evolution

Ans. ***(d)*** Analogous organs arise due to convergent evolution. These are the organs which have similar functions, but are different in their structural details and origin, *e.g.,* wings of insect and bird.

The other three options are incorrect, because divergent evolution give rise to homologous organs, genetic drift can contribute to speciation and artificial selection is used to produce improved varieties of animals and plants.

Q. 7 $(p + q)^2 = p^2 + 2pq + q^2 = 1$, represents an equation used in

(a) population genetics
(b) Mendelian genetics
(c) biometrics
(d) molecular genetics

Ans. ***(a)*** $(p + q)^2 = p^2 + 2pq + q^2 = 1$ represents an equation used in population genetics.

It is a mathematical representation of 'Hardy-Weinberg principle'. This principle says that allele frequencies in a population are stable and is constant from generation to generation, *i.e.,* the gene pool remains a constant.

Q. 8 Appearance of antibiotic-resistant bacteria is an example of

(a) adaptive radiation
(b) transduction
(c) pre-existing variation in the population
(d) divergent evolution

Ans. ***(c)*** Appearance of antibiotic-resistant bacteria is an example of pre-existing variation in the population. When a bacterial population encounters a particular antibiotic, those sensitive to it die.

But some bacteria having mutations become resistant to the antibiotic. Soon, the resistance providing genes become widespread and the entire population becomes resistant.

It is not due to adaptive radiation because adaptive radiation is development of different functional structures from a common ancestral form. Which is also known as divergent evolution.

Transduction is a process whereby, foreign DNA is introduced into another cell *via* a viral vector.

Q. 9 Evolution of life shows that life forms had a trend of moving from

(a) land to water
(b) dryland to wet land
(c) freshwater to sea water
(d) water to land

Ans. ***(d)*** Evolution of life shows that life forms had a trend of moving from water to land. The early vertebrates were fishes (which lived in only water). Some fishes gradually changed into amphibians (can live both on land and in water).

Certain amphibians then transformed into the reptiles (live on land) some of the latter finally evolved into birds (can fly) and than mammals. Thus, showing life forms moved from water to land.

Q. 10 Viviparity is considered to be more evolved because

(a) the young ones are left on their own
(b) the young ones are protected by a thicks shell
(c) the young ones are protected inside the mother's body and are looked after they are born leading to more chances of survival
(d) the embryo takes a long time to develop

Ans. ***(c)*** Viviparity is considered to be more evolved because the youngs ones are protected inside the mother's body and are looked after once they are born, leading to more chances of survival, *e.g.,* mammals.

However, in oviparity, the female lays fertilised/unfertilised eggs covered by a hard calcareous shell in a safe place in the environment. The chances of survival are less as the young ones are left on their own.

Q. 11 Fossils are generally found in

(a) sedimentary rocks
(b) igneous rocks
(c) metamorphic rocks
(d) any type of rock

Ans. ***(a)*** Fossils are generally found in sedimentary rocks, which are formed by the gradual deposition of silt, sand or calcium carbonate over millions of years in regions such as lakes or sea during their formation, the dead animals are carried to the sea or large lake, sink down and get burried in the rocks. The animals, thus preserved in the rocks, are converted into fossils.

Q. 12 For the MN-blood group system, the frequencies of M and N alleles are 0.7 and 0.3, respectively. The expected frequency of MN-blood group bearing organisms is likely to be

(a) 42% (b) 49%
(c) 9% (d) 58%

Ans. ***(a)*** The expected frequency of MN blood group bearings organisms is likely to be 42%.

According to Hardy-Weinberg equation, $p^2 + 2pq + q^2 = 1$

where, p = Frequency of M alleles,

p^2 = Frequency of homozygous dominant individuals.

q = frequency of N alleles

q^2 = Frequency of homozygous recessive individuals.

$2Pq$ = Frequency of heterozygous individuals.

So, $(0.7)^2 + (0.3)^2 + 2\ pq = 1$

$0.49 + 0.09 + 2\ pq = 1$

$\therefore \quad 2pq = 0.42$ = Frequency of heterozygous individuals.

i.e., 42%

Q. 13 Which type of selection is industrial melanism observed in moth, Biston betularia

(a) Stabilising (b) Directional
(c) Disruptive (d) Artificial

Ans. ***(b)*** **Directional selection** is observed in moth, *Biston betularia* is industrial melanism. Under this, individuals at one end of the frequency distribution do well light and so more individuals of that type will be present in next generation.

The other options are incorrect because in **stabilising selection,** average sized individuals are favoured. *e.g.,* weight of new-born babies and in **disruptive selection** both extremes are favoured, while intermediate varieties are eleminated, *e.g.,* black bellied seed cracker, *Pyrenestes ostrinus.*

In artificial selection, the individuals with desirable characteristics are deliberately selected to produce a progeny with all those characteristics.

Q. 14 The most accepted line of descent in human evolution is

(a) *Australopithecus* → *Ramapithecus* → *Homo sapiens* → *Homo habilis*
(b) *Homo erectus* → *Homo habilis* → *Homo sapiens*
(c) *Ramapithecus* → *Homo habilis* → *Homo sapiens*
(d) *Australopithecus* → *Ramapithecus* → *Homo erectus* → *Homo habilis* → *Homo sapiens*

Ans. *(c)* The most accepted line of descent in human evolution is *Ramapithecus→ Homo habilis→ Homo erectus→ Homo sapiens.*

Human Evolution	Characteristics
Ramapithecus	Survived about 14-15 mya, walked erect on its hind legs, arise fro0m *Dryopithecus*.
Australopithecus	Lived from 4-1-5 mya in caves, had omnivorous diet. Fully bipedal hominid
Homo habilis	First human like being Did not eat meat, brain capacity 650-800 cc
Homo erectus	Lived about 1.5 mya Brain capacity around 900 cc, and ate meat
Homo sapiens	Brain capacity averages 1450 cc. Erect posture and limbs straight.

Q. 15 Which of the following is an example for link, species?

(a) Lobe fish (b) Dodo bird
(c) Sea weed (d) Chimpanzee

Ans. *(a)* Lobe fish is an example for link species.

About 350 mya, fish with stout and strong fins could move on land and go back to water. These were called lobe and they evolved into the first amphibians that lived on both land and water, *e.g.,* coelocanth.

Dodo is an extinct flightless bird. Sea weed is multicellular benthic marine algae chimpanzees are the closest living relatives of humans.

Q.16 Match the scientists listed under column I with ideas listed column II.

Column I		Column II	
A.	Darwin	1.	Abiogenesis
B.	Oparin	2.	Use and disuse of organs
C.	Lamarck	3.	Continental drift theory
D.	Wagner	4,	Evolution by natural selection

Codes

	A	B	C	D		A	B	C	D
(a)	1	4	2	3	(b)	4	1	2	3
(c)	2	4	3	1	(d)	4	3	2	1

Ans. *(b)* **Darwin** is related with evolution by natural selection. According to the theory in the struggle for existence, the individuals which have more favourable variations will survive and reproduce, while others, which have less favourable or unfavourable variations will not puripetuate.

Oparin Put forth abiogenesis theory.

According to abiogenesis Life is originated from the non-living things spontaneously.

Lamarck Use and disuse of organs is one of the important principle of Lamarckism.

Wagner proposed continental drift theory.

It states that part of the Earth's crust slowly drift atop a liquid core forming different continents. As these continents had different environmental conditions, so plants and animals evolved.

Q. 17 In 1953 SL Miller created primitive earth conditions in the laboratory and gave experimental evidence for origin of first form of life from pre-existing non-living organic molecules. The primitive earth conditions created include

(a) low temperature, volcanic storms, atmosphere rich in oxygen

(b) low temperature, volcanic storms, reducing atmosphere

(c) high temperature, volcanic storms, non-reducing atmosphere

(d) high temperature, volcanic storms, reducing atmosphere containing CH_4, NH_3 etc.

Ans. ***(d)*** The Miller – Urey experiment tested for the occurrence of chemical evolution by stimulating hypothetical conditions present on early earth.

These primitive earth conditions include high temperature, volcanic storms and reducing environment containing methane (CH_4), ammonia (NH_3), hydrogen (H_2) and water (H_2O).

They ultimately found that a large number of simple organic compounds including some amino acids such as alanine, glycine and aspartic acid can be synthesised in into as during chemical origin of life.

Q. 18 Variations during mutations of meiotic recombinations are

(a) random and directionless (b) random and directional

(c) random and small (d) random, small and directional

Ans. ***(a)*** Variations during mutations of meiotic recombinations are random and directionless.

Hugo de Vries based on his work on evening primrose stated that it is mutation which causes sudden appearance of variations that results in speciation.

He stated that mutations are sudden, heritable and persistant in successive generation. He contradicted Darwinian variations that are small and directional.

Very Short Answer Type Questions

Q. 1 What were the characteristics of life forms that had been fossilised?

Thinking Process

Fossils are formed and preserved over times so, all organisms are not equally likely to fossilis. It is based towards organisms with hard parts such as bones of vertebrates or calcareous exoskeleton of invertebrates.

Ans. The organisms with hard parts are likely to be fossilised, than those who do not have such parts. The harder the material, better it would be preserved soft parts fossils occur rarely, *e.g.,* birds and pterosaurs have very light bones, hollowed out and specialised for flight.

So, they have sparser fossil record as compared to mammals, whose bones are partially mineralised during life.

Q. 2 Did aquatic life forms get fossilised? If, yes where do we come across such fossils?

Thinking Process

The geological changes that took place over time transformed many water-bodies into solid rocks and mountains, so fossils of aquatic organism are more likely to be found in mountains.

And. *Yes*, aquatic forms of life do get fossilised, infact, there are more aquatic than terrestrial fossil organisms. Such fossils of sea creatures are found in mountains as opposed to deep sea beds.

This is because the rocks in which the fossils are found used to be at the bottom of oceans. Due to the changes in the crustal plates over time, the ocean sediments were pushed up to form mountains.

Q. 3 What are we referring to when we say 'simple organisms' or 'complex organisms'?

Ans. These terms are used to classify organisms according to their evolutionary history.

Simple organisms refer to those organisms that have simple structural and functional organisation and are considered primitive, whereas **Complex organisms** refer to those organisms that have higher and complex levels of structural and functional organisation.

These are more advanced and said to have arisen from simple organisms.

Q. 4 How do we compute the age of a living tree?

Ans. *To estimate the age of a living tree, following steps are required*

(i) Measure the circumference of the tree trunk (at about 4.5 feet above the ground).

(ii) Calculate the diameter of the trunk. This is done by dividing the circumference by 3.14. Divide this (*i.e.,* diameter) by 2 to get the radius.

(iii) Determine the growth factor. A tree's growth factor is the measurement of the width it gains annually. The trees's growth factor can be seen from the data available or by measuring the rings of a dead tree from the same species.

(iv) Multiply the diameter and the tree species average growth factor and the so done calculating suggest the approximate age of the tree in years.

Q. 5 Give an example for convergent evolution and identify the features towards which they are converging.

Ans. When unrelated animals converging to the same form or structure, that is very adaptive in their common environment. It is called **convergent evolution,** *e.g.,* Australian marsupials and placental mammals.

Such as (placental wolf and Tasmanian wolf). These two sub-classes of mammals have adapted in similar ways to a particular food supply, locomotor skill or climate.

Their resemblances in overall shape, locomotor mode and feeding and foraging are superimposed upon different modes of reproduction, the feature that accurately reflects their distinct evolutionary relationships.

Q. 6 How do we compute the age of a fossil?

Ans. The age of a fossil can be computed by **radioactive dating** (also called radiometric dating). It is a technique based on a comparison between the observed abundance of a naturally occurring radioactive isotope and its decay products, using known decay rates.

Among the best known techniques are radiocarbon dating, potassium-argon dating and uranium lead dating.

Q. 7 What is the most important pre-condition for adaptive radiation?

Ans. **Conditions promoting adaptive radiation** are much of the diversity of life originated through episodes of adaptive radiation during periods when **ecological space** became available for diversification. There are two primary mechanisms through which ecological space can become available.

(i) intrinsic changes in organisms.

(ii) extrinsic effects, including environmental change and colonisation of isolated landmasses.

Q. 8 How do we compute the age of a rock?

Ans. The age of a rock in years is called its absolute age. It is determined by the natural radioactive decay of certain elements, *e.g.,* uranium, when decays turns into lead. The parent atoms of uranium are converted into daughter atoms of lead over a fixed interval of time. This interval is the **decay constant**.

The ratio of parent-daughter atoms changes in a quantity that can be measured.

The **radioactive half-life** (the amount of time required for one half of the parent atoms to beonverted to daughter atoms) is used to calculate the age of the rock.

Q. 9 When we talk of functional macromolecules (*e.g.,* proteins as enzymes, hormones, receptors, antibodies etc), towards what are they evolving?

Ans. Functional macromolecules are evolving towards creation of a complex organism. There are various evidences that are common to simple and complex forms of lite indicate common ancestry, *e.g.,* histones protein tend to be well preserved among all eukaryotes, from amoebas to blue whale or to humans, with only one or two amino acids different.

The genetic code is nearly identical for all known life forms, from bacteria to archaea or animals and plants.

Q. 10 In a certain population, the frequency of three genotypes is as follows

Genotypes	BB	Bb	bb
Frequency	22%	62%	16%

What is the likely frequency of B and b alleles?

Thinking Process

According to Hardy-Weinberg equilibrium, $p^2 + 2pq + q^2 = 1$.

Ans. The likely frequency of B = BB + 1/2 Bb

$$= \left[22 + \frac{62}{2}\right]\%$$

$$= 53\%$$

The likely frequency of b = bb + 1/2 Bb

$$= \left[16 + \frac{62}{2}\right]\%$$

$$= 47\%$$

Q. 11 Among the five factors that are known to affect Hardy-Weinberg equilibrium, three factors are gene flow, genetic drift and genetic recombination. What are the other two factors?

Ans. The other two factors that affect Hardy-Weinberg equilibrium are **mutation** and **natural selection**.

Mutation is a sudden heritable change in an organism which is generally due to change in the base sequence of the nucleic acid in the organism's genome.

Microbial experiments show that pre-existing advantageous mutations when selected will result in formation of new phenotypes. Over few generations, this would result in speciation. Thus, resulting in changed frequency of genes and alleles.

Natural selection is a phenomenon by which organisms possessing heritable variations enabling their better survival reproduce and leave greater number of progeny than their counterpart.

It can lead to stabilisation (in which more individuals acquire mean character value), directional change (more individuals acquire value other than the mean character value) or disruption (more individuals acquire peripheral character value at both ends of the distribution curve).

Q. 12 What is founder effect?

Ans. Sometimes, a small number of individuals become isolated from a larger population to form a new population at some distance away from their place of origin.

The gene pool of the new population differs from the source population. It is possible that the change in allele frequency is so drastically different in the new sample that they become a different species. The original driftted population becomes **founders** and this effect is called **founder effect**.

Q. 13 Who among the *Dryopithecus* and *Ramapithecus* was more man like?

Ans. *Ramapithecus* was more man-like. It walked erect on its hind legs, ate hard nuts and seeds like modern man and had jaws and teeth similar to humans. It arose from *Dryopithecus*, which was considered to be a common ancestor of man and apes.

Dryopithecus was more ape-like with same length of arms and legs.

Q. 14 By what Latin name, the first Hominid was known?

Ans. The first hominid was known as *Homo habilis*. The brain capacities were between 650-800cc. They probably did not eat meat.

Q. 15 Among *Ramapithecus*, *Australopithecines* and *Homo habilis* who probably did not eat meat?

Ans. *Homo habilis* probably did not eat meat. This creature was the first human like being, with brain capacities between 650-800cc.

Short Answer Type Questions

Q. 1 Louis Pasteur's experiments, if you recall, proved that life can arise from only pre-existing life. Can we correct this as life evolves from pre-existent life or otherwise we will never answer the question as to how the first forms of life arose? Comment.

Ans. *Yes*, we can correct this as life evolves from pre-existent life. The first life that appeared on earth was apparently the result of chemical evolution, *i.e.,* the life originated from inorganic molecules which formed organic molecules, further forming complex compounds.

This finally resulted into simple cells and then simple organisms, wherein complexity development with time. However, once life originated, abiogenesis could not follow, and hence, life evolved further only through biogenesis, *i.e.,* pre-existent life gave rise to new life.

Q. 2 The scientists believe that evolution is gradual. But extinction, part of evolutionary story, are 'sudden' and 'abrupt' and also group-specific. Comment whether a natural disaster can be the cause for extinction of species.

Ans. *Yes*, a natural disaster can be the cause for extinction of species. As new species evolve to fit ever changing ecological niches, older species fade away. But, the rate of extincition is far from constant.

In last 500 million years, 50 - 90% or more of all species on earth have disappeared in a geological blink of the eye. Many times, these mass extinctions had been the consequence of a natural disaster.

The most studied mass extinction between the Cretaceous and Palaeocene periods about 65 million years ago, killed off the dinosaurs and made room for mammals to rapidly diversify and evolve. The cause is suspected to be volcanic eruptions and impact of large asteroids or comets striking the earth.

Q. 3 Why is nascent oxygen supposed to be toxic to aerobic life forms?

Ans. Nascent oxygen is very reactive and can react with different biomolecules. Nascent oxygen is a permanent oxidising agent. It is highly reactive and can react readily with different kind of molecules including DNA, proteins present in the cells of aerobic life forms.

It is thus, considered toxic if it reacts with DNA, it can lead to mutations and defective proteins, both structural and functional. Similarly if it reacts with proteins and enzymes, they are degraded and many metabolic pathways may hence be impaired.

Q. 4 While creation and presence of variation is directionless, natural selection is directional as it is in the context of adaptation. Comment.

Ans. The creation and presence of variations is directionless in regard that they occur randomly and spontaneously. The variations which are helpful in the adaptations of an organism towards its surroundings would be passed on to next generations.

Natural selection is the most critical evolutionary process, which can be considered directional as it leads to only one path that is selection and perpetuation of better adapted individuals. Natural selection leads to survival of the fittest and disappearance of all those organisms which do not all fit in the preveling environmental conditions.

Q. 5 The evolutionary story of moths in England during industrialisation reveals, that 'evolution is apparently reversible'. Clarify this statement.

Thinking Process

The peppered moths were initially white coloured, then black coloured due to industrialisation. In recent years, the light coloured moths are increasing in population again.

Ans. During the last century in the industrial regions of England, a light coloured peppered moth *Biston betularia* was found on the bark of trees. The tree bark was covered by whitish lichens, so light coloured moths escaped unnoticed from predatory birds.

After industrialisation, barks got covered by smoke, so the white moths were selectively picked up by birds. However, the black coloured moths escaped unnoticed against a dark background and became abundant.

However, in recent years, reduced industrial pollution has led to the growth of lichens again and thus, the population of light coloured moths is again increasing.

This evolutionary story of moths in England, thus reveals, that 'evolution is apparently reversible'

Q. 6 Comment on the statement that 'evolution and natural selection are end result or consequence of some other processes, but themselves are not processes'.

Ans. Evolution helps us to understand the history of life. We can view evolution as a pattern of evolutionary change and as a process as well.

The world we see, all the inanimate and animate, is only the success stories of evolution. When we describe the story of this world, we describe evolution as a process.

On the other hand, when we describe the story of life an earth, we treat evolution as a consequence of a process called natural selection. Natural selection is the outcome of favourable variations among organisms and environmental conditions.

Thus, we are still not very clear whether to regard evolution and natural selection as processes or end result of processes.

Q. 7 State and explain any three factors affecting allele frequency in populations.

Ans. *Factors affecting allele frequency in populations are as described below*

(i) **Mutations** These are sudden heritable changes which are supposed to be the primary source of genetic variation. *They are of following two types*

(a) **Chromosomal Mutations** They arise due to changes in chromosome number and changes in structure.

(b) **Gene Mutations** These are changes in gene structure and expression due to addition, deletion, substitution or inversion of nucleotides.

(ii) **Non-random Mating** Repeated mating between individuals of certain selected traits changes the gene frequency, *e.g.,* selection of more brightly coloured male bird by a female bird may increase the gene frequency of bright colour in the next generation.

(iii) **Gene Flow** (Gene Migration) It is the movement of alleles into and out of a gene pool. Breeding of immigrants with the host population adds new alleles to the gene pool of the host population.

Q. 8 Gene flow occurs through generations. Gene flow can occur across language barriers in humans. If we have a technique of measuring specific allele frequencies in different population of the world, can we not predict human migratory patterns in pre-history and history? Do you agree or disagree? Provide explanation to your answer.

Ans. *Yes*, we agree. As the gene flow occurs through geographical barriers over generations, by studying specific allelic frequencies in various populations of the world, we can predict the human migratory patterns in pre-historic and historic era.

There have been projects undertaken such as human genographics project. Which uses data from studies on specific genes/chromosomes/mitochondrial DNA to trace the evolutionary history and migratory patterns of humans.

Q. 9 How do you express the meaning of worlds like race, breed, cultivars or variety?

Ans. *The meaning of the given words are as given below*

Race It is a classification system used to categorise humans into large and distinct populations or groups by anatomical, cultural, linguistic, geographical, historical and for relegious relationship.

Breed It is a specific group of domestic animals or plants having homogenous appearance, homogenous behaviour and other characteristics that distinguish it from other animals or plants of the same species and that were arrived at through selective breeding.

Cultivar It is a plant or grouping of plants selected for desirable characteristics that can be maintained by propogation. 'Cultivar' stands for 'cultivated variety'.

Variety A variety arises naturally in the plant kingdom and plant grown from its seeds will typically come out true to type.

Q. 10 When we say 'survival of the fittest', does it mean that

(a) those which are fit only survive

(b) those that survive are called fit? Comment.

Thinking Process

Those individuals which survice and reproduce in their respective environment are called fit.

Ans. In the struggle for existence, the individuals which have more favourable variations will enjoy a competitive advantage over others which have less favourable or unfavourable variations.

They are considered fit and thus, will survive and reproduce. Such individuals produce more progeny (with more fit individuals) than others who are less adapted in that environment.

Q. 11 Enumerate three most characteristic criteria for designating a Mendelian population.

Ans. *Characteristic criteria for designating a Mendelian population are*

(i) Population must be sufficiently large.

(ii) Population must have potentialities for free flow of genetic material among individuals, through sexual reproduction.

(iii) Migration should either be nil or negligible.

Q. 12 'Migration may enhance or blurr the effects of selection' comment.

Ans. The movement of individuals from one place to another is called **migration**. It can be the movement of individuals to a different populations (*i.e.,* emigration) or movement of individual into a particular population (*i.e.,* cmmigration) Migration may bring in more such alleles, that bestow upon the individuals, such adaptations or traits which are selected by nature. Thus, enhancing the effect of selection.

Similarly, emigration may lead to removal of such alleles that confer better adaptations. Immigration may also bring in those alleles which confer the traits that are not selected by nature, *i.e.,* blurr the effects of selection.

Hence, it is justifiable to say that 'Migration may enhance or blurr the effects of selection.'

Long Answer Type Questions

Q. 1 Name the law that states that the sum of allelic frequencies in a population remains constant. What are the five factors that influence these values?

Ans. **Hardy-Weinberg Principle** states that the sum of allelic frequencies in a population is stable and is constant from generation to generation, *i.e.,* the gene pool (total genes and their alleles in a population remains constant. This is called genetic equilibrium. *The sum total of all the allelic frequencies is*

Five factors that influence these values are

(i) **Gene Migration or Gene Flow** When migration of a section of population to another place occurs, gene frequencies change in the original as well as in the new population. New genes/alleles are added to the new population and these are lost from the old population. There would be gene flow if this gene migration, happens multiple times.

(ii) **Genetic Drift** It refers to the elimination of the genes of certain traits when a section of population migrates or dies of natural calamity. It is an evolutionary force operating in small populations whereby gene frequency changes by chance leadings to loss of some genes or gain of others irrespective of their selective advantages or disadvantages.

(iii) **Mutation** The sudden heritable change which is directionless in gene is called mutation. It alters the genetic frequency or genetic make up of an individual.

(iv) **Genetic Recombination** This phenomenon occurs during gamete formation when chromosomes pass from parents to offsprings which show new combination of characteristics.

(v) **Natural Selection** It is a phenomenon by which some members of population having traits that enable them to grow and reproduce at higher rater are favoured. Hence, they leave more surviving offspring in the next generation than others.

Q. 2 Explain divergent evolution in detail. What is the driving force behind it?

Ans. **Divergent evolution** is the evolution of a number of different forms of animals or plants froms of a common ancestral form. The driving force behind, it is adaptations to newly involved habitat and the prevailing environmental conditions there. As the original population increases in size, it spreads out from its centre of origin to exploit new habitas and food resources.

In time this results in a number of populations each adapted to its particular habitat, eventually these populations will differ from each other sufficiently to become new species.

A good example of this process is the evolution of the Australian marsupials into species adapted as carnivores, herbivores, burrowers, fliers, etc. Another example is that of peritadactyl limb in mammals.

The flipper of a seal, wing of a bat, forelimb of a male, front legs of horse and the arm of a man perform different functions, but exhibit the same structural plan including same pentadactyl pattern of bones.

Q. 3 You have studied the story of peppered moths in England. Had the industries been removed, what impact could it have on the moth population? Discuss.

Thinking Process

Prior to industrialisation, the light coloured moths were prevalent and well adapted to lichen covered trunks of trees.

Ans. In the population of pepper moth two variants exist the dark and the light coloured. Before industrialisation, the light coloured moths were prevalent because they blended well with the lichen covered bark of the trees.

The predators were unable to spot them and hence, their population were more in number. With industrialisation, the barks got covered with soot. The growth of lichens reduced, the light coloured moths were thus, spotted by the predators and their number decreased.

However, the black variants were camouflased better on soot covered barks and their number increased drastically.

If the industries were removed, the population of black moths would have declined because as stated before, they would not be able to camouflage against a light background (no black soot). Also the growth of lichens would increase. Therefore, the dark variants would be spotted better by predators and be eaten more frequently.

Q. 4 What are the key concepts in the evolution theory of Darwin?

Ans. *Key concepts of Darwin's theory of evolution are as follows*

(i) **Over Production** Living beings have an innate ability of producing own kind for the continuity of race. It has been observed that more individuals of each kind are produced than could possibly survive.

(ii) **Struggle for Existence** Individuals multiply in geometric ratio, whereas space and food remain almost limited.

(iii) **Variations** Members of a population vary is size, form and other characteristics even though they look superficially similar, no two individuals are alike. These variations are gradual and those with adaptive value are passed on to next generation.

(iv) **Survival of the Fittest and Natural Selection** During struggle for existence only those individuals could survive which exhibit beneficial variations and adapt better to changing environment. This is known as natural selection.

(v) **Origin of Species** Natural Selection results in modification of traits within a lineage, which over a period of long time can bring about evolution of original species into new one.

Q. 5 Two organisms occupying a particular geographical area (say desert) show similar adaptive strategies. Taking examples, describe the phenomenon.

Ans. This phenomenon indicated in the question is convergent evolution where by organisms, not closely related, evolve similar traits independently as a result of adaptation to similar environment. *e.g.,*

(i) Streamlined shape of sharks and dolphins. The former is a fish, while dolphin is a mammal, but both of them depend on swift movement through the water, so a streamlined shape is essential. Thus, it is the similar habitat that resulted in selection of similar adaptive features in different groups of organisms, but toward the same function.

(ii) Spines (modified leaves) and thorns (modified stems), both look similar and provide protection to the plant, but the plants to which they belong are distantly related.

Q. 6 We are told that evolution is a continuing phenomenon for all living things. Are humans also evolving? Justify your answer.

Ans. New research suggests that despite modern technology and industrialisation, 'humans continue to evolve'. In the last 10,000 years or so, the pace of our evolution has speeded up 100 times creating more mutations in our genes and hence, greater natural selection.

Some clues that show humans are evolving are

(i) **Lactose Tolerance** Historically the gene that regulated human's ability to digest lactose was shut down as infants are weaned off of their mother's breast milk. However, adult human in regions of Africa and Northern Europe developed the ability to tolerate lactose in their diets as recent as 5,000 or 6,000 years ago due to mutations.

(ii) **Wisdom Teeth** Our ancestors had much bigger jaws than we do to lactose their eating habits. Today our jaws are much smaller and wisdom teeth are often impacted estimates say that they will disappear in the coming population.

Q. 7 Had Darwin been aware of Mendel's work would he been able to explain the origin of variations. Discuss.

Ans. *Yes*, had Darwin been aware of **Mendel's** work, he would have been able to explain the origin of variations. Darwins observation of different forms of an individual in a population could be related to the presence of different forms of alleles of a gene.

The gene express as the most adaptive traits are selected naturally and become more abundant than those that are expressed as less adaptive traits.

Over the time, the accumulation of these traits might change the species to an extent that it develops into a new one and adapted to the specific environment.

5

Principle of Inheritance and Variations

Multiple Choice Questions (MCQs)

Q. 1 All genes located on the same chromosome

(a) form different groups depending upon their relative distance
(b) form one linkage group
(c) will not from any linkage group
(d) form interactive groups that affect the phenotype

Ans. ***(b)*** All the genes, present on a particular chromosome form a linkage group. The number of linkage group of a species correspond to the total number of different chromosomes of that species. It is not simply the number of chromosomes in haploid set.

e.g., in human male=22 pairs of autosomes + 1X-chromosome + 1Y-choromosme *i.e.,* 24 linkage groups and in female = 22 pairs autosomes + 2X-chromosomes *i.e.,* 23 linkage groups.

While options (a), (c) and (d) are incorrect.

Q. 2 Conditions of a karyotype $2n \pm 1$ and $2n \pm 2$ are called

(a) aneuploidy
(b) polyploidy
(c) allopolyploidy
(d) monosomy

Thinking Process

Numerical changes in chromosome number are referred to as changes in ploidy.

Ans. ***(a)*** Aneuploidy involves changes in chromosome number by additions or deletions of less than a whole set. In this case organism gains or loses one or more chromosomes but not a complete set. Polyploidy is defined as the addition of entire set of chromosome. The polyploidy can be triploidy (3*n*), tetraploidy (4*n*), pentaploidy (5*n*), etc.

Allopolyploidy is the polyploidy in which chromosome sets are non-homologous. In other words we can say that the allopolyploids are derived from a stock which is heterozygous. Monosomy is the process in which one chromosome is removed from diploid set of chromosome (2*n*-1).

Q. 3 Distance between the genes and percentage of recombination shows

(a) a direct relationship
(b) an inverse relationship
(c) a parallel relationship
(d) no relationship

Thinking Process

Crossing over (recombination) is the mutual exchange of the corresponding segments of the adjacent paternal and maternal chromatids of the synapsed homologous chromosomes producing new combinations of genes.

Ans. ***(a)*** Crossing over separates genes away from each other. So, the distance between the genes and percentage of recombination shows an direct relationship, *i.e.,* when genes are close together they have high linkage and exhibit low recombination frequencies.

Thus, the other option are wrong as it does not show parallel or inverse relationship.

Q. 4 If a genetic disease is transferred from a phenotypically normal but carrier female to only some of the male progeny, the disease is

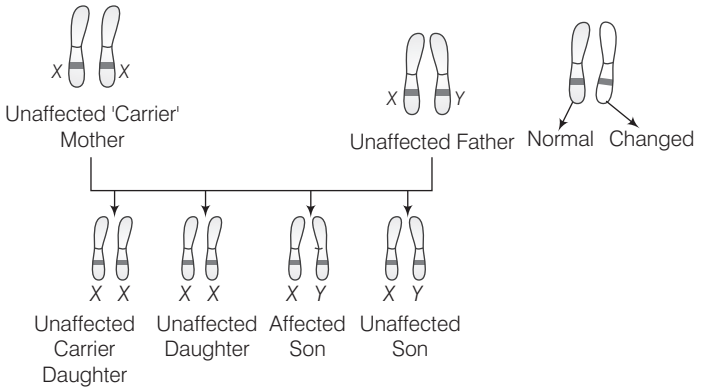
(a) autosomal dominant
(b) autosomal recessive
(c) sex-linked dominant
(d) sex-linked recessive

Thinking Process

Sex-linked disorders are those genetic diseases where the defective genes are carried on either the X or Y-chromosomes.

Ans. ***(d)*** Most sex-linked (X-linked) conditions are recessive. This means that in a person with two X-chromosomes (females), both copies of a gene (*i.e.,* one on each X-chromosome), must have a change or mutation whereas in a person with one X-chromosomes (males), only one copy of a gene must have a mutation.

A female with a mutation in one copy of a gene on the X-chromosome is said to be a 'carrier' for an X-linked condition.



For X-linked recessive disorders, an unaffected carrier mother who has a mutation in a gene on the X-chromosome can transmit either the X-chromosome with this mutation or a normal X-chromosome to her children.

Autosomal dominant inheritance refers to the pattern of inheritance of a condition directly or indirectly due to a dominant faulty gene located on autosome.

Autosomal recessive inheritance is the condition caused directly or indirectly due to a recessive faulty gene copy on autosome.

Sex-linked dominant is a rare trait that is caused by a single abnormal gene on the X-chromosome.

Q. 5 In sickle-cell anaemia glutamic acid is replaced by valine. Which one of the following triplet codes for valine?

(a) G G G (b) A A G (c) G A A (d) G U G

Ans. ***(d)*** Sickle-cell anaemia is an autosome linked recessive trait. This disease is controlled by a single pair of allele Hb^A and Hb^S only the homozygous individuals for Hb^S, *i.e.,* $Hb^S Hb^S$ shows the diseased phenotype. The heterozygous individuals are carriers ($Hb^A Hb^S$).

Due to point mutation, glutamic acid (Glu) is replaced by valine (Val) at sixth position of β-chain of haemoglobin molecule. This substitution occurs due to the single base substitution of the beta globin gene from GAG (Glu) to GUG (Val).

Whereas, the other codes GGG, AAG, GAA do not codes for valine.

Q. 6 Person having genotype $I^a I^b$ would show the blood group as AB. This is because of

(a) pleiotropy (b) codominance

(c) segregation (d) incomplete dominance

Thinking Process

The alleles which are able to express themselves independently when present together are called codominant alleles and this biological phenomenon of expressing together is called codominance.

Ans. ***(b)*** A B O blood grouping in humans is an example of codominance. A B O blood groups are controlled by gene I. Gene I has three alleles I^A, I^B and $I^{oi.\ IA}$ and I^B are the dominant alleles. When I^A and I^B are present together, both express equally and produce the surface antigens A and B, whereas I is the recessive allele and does not produce any antigen.

Pleiotropy referred the genetic effect of a single gene on multiple phenotypic traits.

Incomplete dominance is a genetic term in which does not completely dominate another allele.

Segregation is the separation of allele during the process of gametogenesis. This is the basis of reappearance of recessive character in F_2-generation.

Q. 7 ZZ/ZW type of sex determination is seen in

(a) platypus (b) snails (c) cockroach (d) peacock

Thinking Process

In birds the ZW case i.e., ZZ/ZW type of sex determination is seen.

Ans. ***(d)*** In ZZ/ZW case, the female has heteromorphic (ZW) sex chromosomes and the male has homomorphic (ZZ) sex chromosomes. Thus, peacock shows ZZ/ZW sex determination type.

In platypus the sex determination is of XX-XY type. Both male and females has ten sex chromosome each. The male has XY, XY, XY, XY, XY and female has XXXXXXXXXX.

In snails the sex determination is environmentally induced, while in cockroaches it is of XX-XO types.

In this type Y-chromosome is completely lacking. In this the presence pf unpaired X-chromosomes determines the masculine sex.

Q. 8 A across between two tall plants resulted in offspring having few dwarf plants. What would be the genotypes of both the parents?

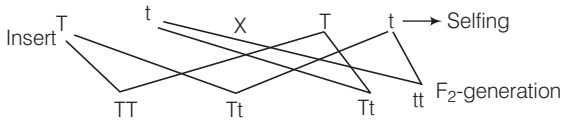
(a) TT and Tt (b) Tt and Tt (c) TT and TT (d) Tt and tt

Thinking Process

On the basis of monohybrid cross (a cross involving only one trait) Mendel formulated the law of segregation.

Ans. ***(b)*** Tt and Tt let's use Mendel's cross of tall and dwarf pea plants as an example.

The F_1 plants of genotype Tt are self-pollinated.(both tall (T) but with dwarf (t) alleles).



Phenotypic ratio : Tall : Dwarf

3 : 1

Genotypic ratio : Pure tall : Hybrid : Pure dwarf

1 : 2 : 1

The letters T and t are used to represent the alleles of the gene that determine plant height by conventions. The upper case letter (T) represents the dominant allele and the recessive allele (t) is represented by the same letter in lower case.

Thus, the tall parents plants having heterozygous alleles, results in offsprings which comprises of both tall and dwarf plants.

For the parental cross, both the parents are true breeding plants, the tall plant is homozygous for the tall allele 'T', while the dwarf plant is homozygous for the dwarf allele 't'. Mendel tracked each trait through two generations.

When true breeding plants were crossed to each other, this is called a parental cross and offspring comprise the first filial or F_1-generation. When the members of the F_1-generation were crossed, this produced the F_2-generation or second filial generation.

A cross between true breeding tall and dwarf plants of the parent generation yield phenotypically tall plants.

The cross between TT and Tt is called **back cross**, which results into two homozygous and two heterozygous dominant gametes. The cross between Tt and tt is called **test cross** which results into 1:1 ratio of gametes.

Q. 9 In a dihybrid cross, if you get 9 : 3 : 3 : 1 ratio it denotes that

(a) the alleles of two genes are interacting with each other

(b) it is a multigenic inheritance

(c) it is a case of multiple allelism

(d) the alleles of two genes are segregating independently

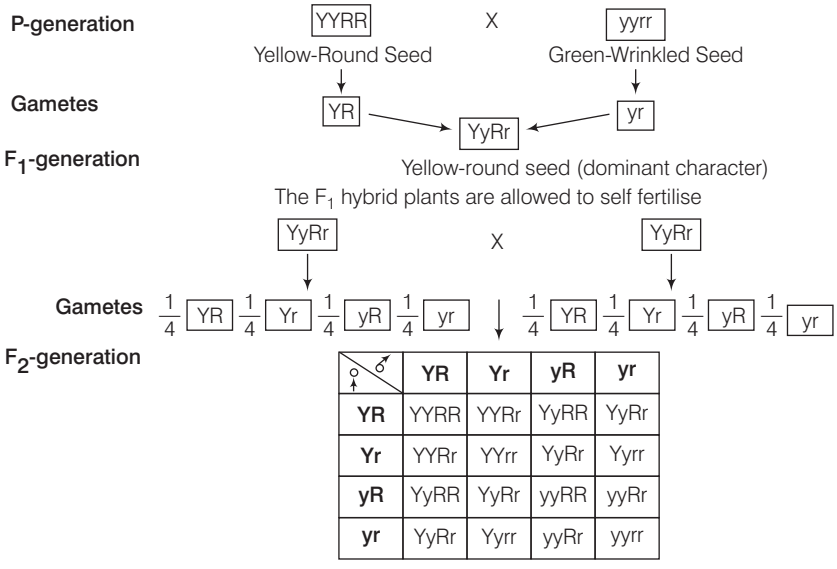
Thinking Process

A cross that involves the analysis of two independent traits is termed a dihybrid cross. The law of independent assortment was deduced from Mendel's experiment with dihybrid cross.

Ans. ***(d)*** Alleles of two genes are segregating independently. It can be explained as. Suppose crosses are made between a pea plant with round and yellow seeds and one with wrinkled and green ones.

All F_1 hybrids give yellow and round seeds. Since yellow colour is dominant over the green and the round shape is dominant over the wrinkled.

When the F_1-hybrid plants are crossed to each other or allowed to self fertilise, an F_2-*generation form as represented in the following figure*



♀ \ ♂	YR	Yr	yR	yr
YR	YYRR	YYRr	YyRR	YyRr
Yr	YYRr	YYrr	YyRr	Yyrr
yR	YyRR	YyRr	yyRR	yyRr
yr	YyRr	Yyrr	yyRr	yyrr

Phenotypic ratio – 9 : 3 : 3 : 1

The outcome of the dihybrid cross make it very clear that segregation of the seed colour is independent of the seed shape and both the parental and new combinations of the characters appear in the F_2 offspring, *i.e.,* assortment of genes of one pair is independent of the other pair.

When the alleles of two genes are interacting with each other one may dominate over other or become recessive. During a multigenic inheritance we describe a characteristics that is specified by a combination of multiple genes. Multiple allelism is a type of non-mendelian inheritance pattern that involves more than just the typical two alleles.

Q. 10 Which of the following will not result in variations among siblings?

(a) Independent assortment of genes (b) Crossing over
(c) Linkage (d) Mutation

Thinking Process

Linkage refers to the physical association of genes on chromosome.

Ans. ***(c)*** Linkage will not result in variations among siblings. Morgan carried out several dihybrid crosses in *Drosophila* to study genes that were sex-linked.

Morgan came to know that the genes were located on the X-chromosome and also observed that when the two genes in a dihybrid cross were situated on the same chromosome, the proportion of parental gene combinations were much higher than the non-parental type.

It indicates that due to the physical association of the two genes. There will be no variations among siblings. Independent assortment of genes means that allele pair separate during the formation of gametes independently. It means that traits are transmitted to offspring independently of one another.

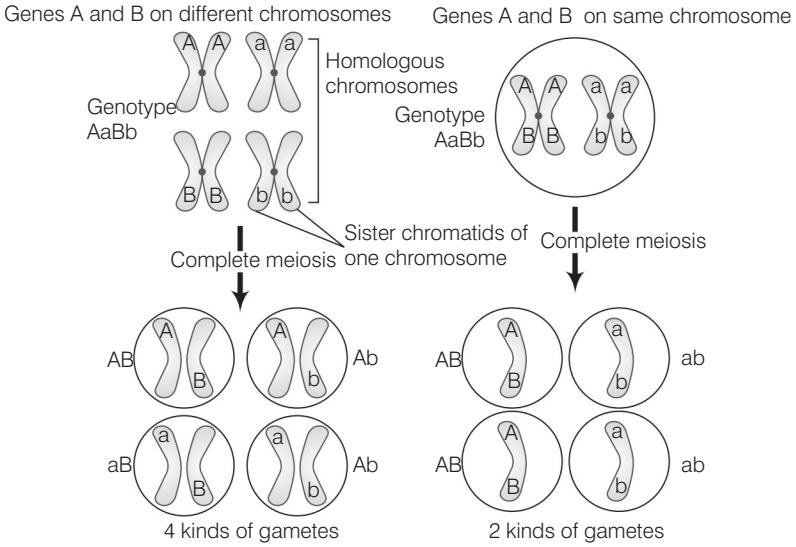
Crossing over is the exchange of genetic material between homologous chromosomes. It is one of the final phases of genetic recombination. Mutation is the sudden inheritable change in genetic material of an organism which transfers to next generation.

Q. 11 Mendel's law of independent assortment holds good for genes situated on the

(a) non-homologous chromosomes (b) homologous chromosomes
(c) extra nuclear genetic element (d) same chromosome

Ans. ***(a)*** **Non-homologous Chromosome** The law of independent assortment holds true as long as two different genes are on separate chromosomes. When the genes are on separate chromosom, the two alleles of one gene (A and a) will segregate into gametes independently of the two alleles of the other gene (B and b).

Equal numbers of four different gametes will form AB, aB, Ab,ab. But if the two genes are on the same chromosome, then they will be linked and will segregate together during meiosis, producing only two kinds of gametes.



Homologous chromosomes are similar but not identical. Each carries the same gene in same order but the alleles for each trait may not be the same. Extranuclear genetic elements are also called as plasmids and shows the pattern of maternal inheritance.

Q. 12 Occasionally, a single gene may express more than one effect. The phenomenon is called

(a) multiple allelism (b) mosaicism
(c) pleiotropy (d) polygeny

Ans. ***(c)*** Occasionally, a single gene may express more than one trait. This phenomenon is called pleiotropy. Sometimes, one trait will be very evident and others will be less evident, *e.g.,* a gene for white eye in *Drosophila* also affect the shape of organs in male responsible for sperm storage as well as other structures.

Similarly, sickle-cell anaemic individuals suffer from a number of problems, all of which are pleiotropic effects of the sickle-cell alleles.

Multiple allelism is a seies of three or more alternative or allelic forms of a gene, only two of which can exist in any normal diploid individual, *e.g.,* genes of blood groups in humans.

Mosaicism describes the occurrence of cells that differ in thier genetic component from other cells of the body.

Polygeny refers to a single characteristic that is controlled by more than two genes. (it is also known as multifactorial inheritance).

Q. 13 In a certain taxon of insects some have 17 chromosomes and the others have 18 chromosomes. The 17 and 18 chromosome-bearing organisms are

(a) males and females, respectively
(b) females and males, respectively
(c) all males
(d) all females

Ans. ***(a)*** In certain insects, such as cockroach, and some roundworms, the Y-chromosome is missing so that the male has only one sex chromosome, *i.e.,* 'X'. The condition in the male is XO (O means absence of one sex chromosome) and in the female it is XX., thus males showing 17 chromosomes while females show 18 chromosome.
All the other option given are wrong.

Q. 14 The inheritance pattern of a gene over generations among humans is studied by the pedigree analysis. Character studied in the pedigree analysis is equivalent to

(a) quantitative trait
(b) Mendelian trait
(c) polygenic trait
(d) maternal trait

Thinking Process

A pedigree is a family tree that diagrams the relationships among parents and children across several generations which shows the inheritance pattern of a particular phenotyphic character.

Ans. ***(b)*** Mendelian inheritance in humans is difficult to study. Current understanding of mendelian inheritance in humans is gained by analysis of family pedigrees or the results of matings that have already occured. By analysing a pedigree, we may be able to predict how the trait is inherited.

It is a visual tool for documenting the biological relationship in families and to determine the mode of inheritance (dominant, recessive etc.,) of genetic diseases.

Whereas quantitative trait, polygenic trait and maternal traits are not studied by pedigree analysis.

Continuous traits are often measured and given a quantitative value, they are often referred as quantitative traits, *e.g.,* crop yield, weight, gain in animals, IQ, etc.

Polygenic traits are another exception to mendels rule, which occurs when a trait is controlled by more than one gene. This means that each dominant allele adds to the expression of the next dominant allele.

Maternal traits are the traits inherited and expressed from the maternal parent to the subsequent offsprings.

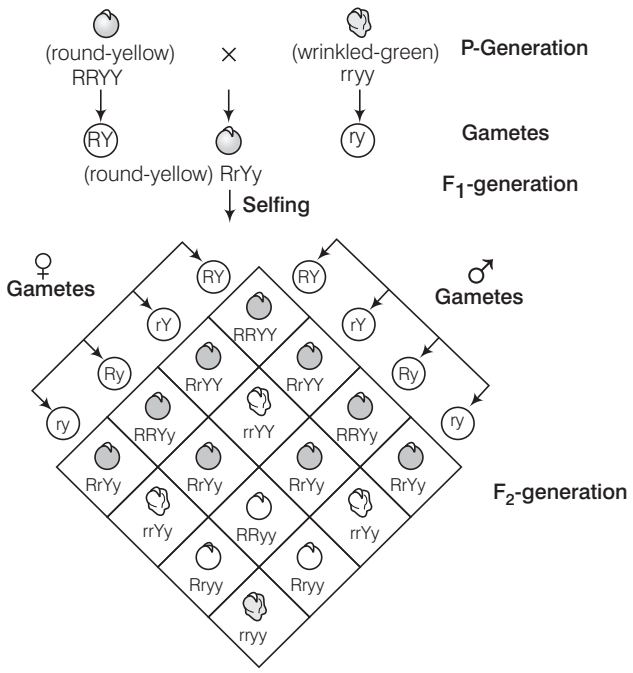
Q. 15 It is said that Mendel proposed that the factor controlling any character is discrete and independent. This proposition was based on the

(a) results of F_3-generation of a cross
(b) observations that the offspring of a cross made between the plants having two contrasting characters shows only one character without any blending
(c) self-pollination of F_1 offsprings
(d) cross-pollination of F_1-generation with recessive parent

Thinking Process

Law of segregation states that the factors or alleles of a pair segregate from each other during gamete formation, such that a gamete receives only one of the two factors. They do not show any blending.

Ans. ***(b)***



Phenotypic ratio	Round yellow			:	Round green			:	Wrinkled yellow			:	Wrinkled green			
	9			:	3			:	3			:	1			
Genetypic ratio	1	:	2	:	2	:	4	:	1	:	2	:	1	:	2	:	1

Results of a dihybrid cross where the two parents differed in two pairs of contrasting traits seed colour and seed shape

Rest of the options does not support the Mendel's low of segregation.

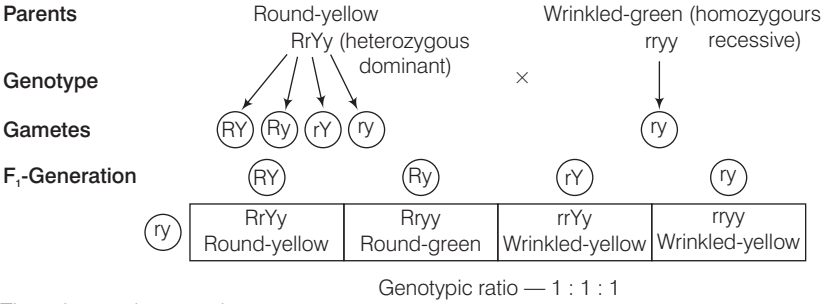
Q. 16 Two genes 'A' and 'B' are linked. In a dihybrid cross involving these two genes, the F_1 heterozygote is crossed with homozygous recessive parental type (aa bb). What would be the ratio of offspring in the next generation?

(a) 1 : 1 : 1 : 1 (b) 9 : 3 : 3 : 1 (c) 3 : 1 (d) 1 : 1

Thinking Process

When a progeny of F_1 *is crossed with the homozygous recessive parent, it is called test cross.*

Ans. ***(a)*** **1:1** It can be explained by the following test cross.



Genotypic ratio — 1 : 1 : 1

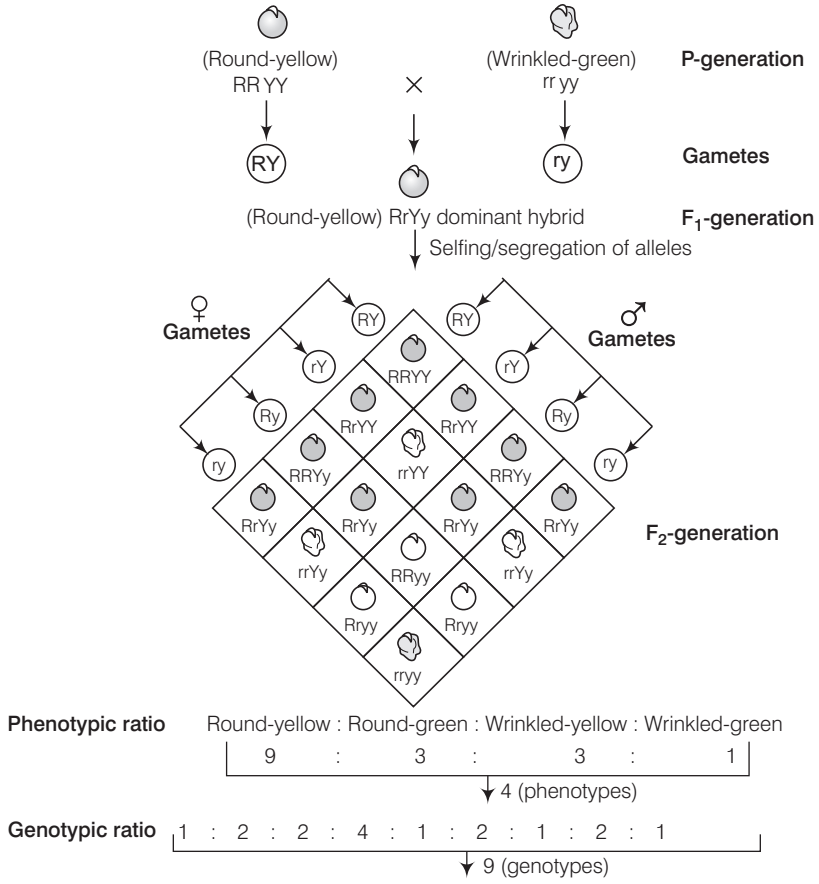
The other options are incorrect.

Q. 17 In the F_2-generation of a Mendelian dihybrid cross the number of phenotypes and genotypes are

(a) phenotypes-4, genotypes-16 (b) phenotypes-9, genotypes-4

(c) phenotypes-4, genotypes-8 (d) phenotypes-4, genotypes-9

Ans. ***(d)*** Mendel's dihybrid cross



Phenotypic ratio Round-yellow : Round-green : Wrinkled-yellow : Wrinkled-green

9 : 3 : 3 : 1

4 (phenotypes)

Genotypic ratio 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

9 (genotypes)

Results of a dihybrid cross where the two parents differed in two pairs of contrasting traits : seed colour and seed shape

Other combinations do not show dihybrid cross ratio of mendelien inheritance.

Q. 18 Mother and father of a person with 'O' blood group have 'A' and 'B' blood group respectively. What would be the genotype of both mother and father?

(a) Mother is homozygous for 'A' blood group and father is heterozygous for 'B'

(b) Mother is heterozygous for 'A' blood group and father is homozygous for 'B'

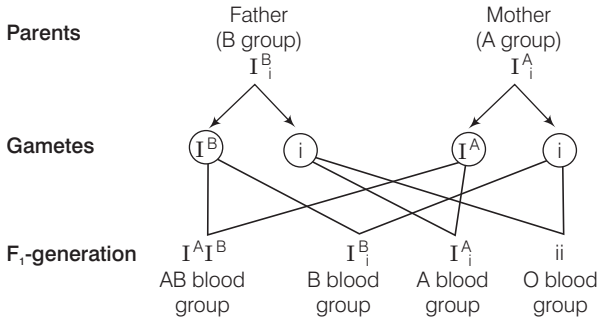
(c) Both mother and father are heterozygous for 'A' and 'B' blood group respectively

(d) Both mother and father are homozygous for 'A' and 'B' blood group respectively

Thinking Process

The child with blood group O will have homozygous recessive alleles. Therefore, both the parents should be heterozygous, i.e., the genotype of father will be $I^A i$ and of mother will be $I^B i$.

Ans. *(c)* When a cross is carried out between heterozygous father (for blood group B) and heterozygous mother (of blood group A) to get four children with different blood groups.



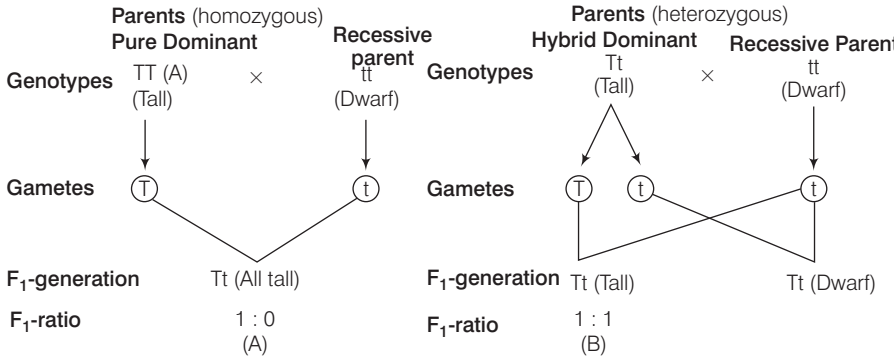
All the four blood groups are controlled by three allelic genes I^A, I^B, i and thus it shows phenomenon of multiple allelism. Both I^A and I^B is dominant over i. However , when together, both are dominant and show the phenomenon of codominance forming the blood group AB. Six genotypes are possible with combination of these three alleles. Thus, other option are wrong or incorrect.

Very Short Answer Type Questions

Q. 1 What is the cross between the progeny of F_1 and the homozygous recessive parent called? How is it useful?

Ans. When a progeny of F_1 is crossed with the homozygous recessive parent, it is called test cross.

Test cross between pure dominant (A) and hybrid dominant (B) individuals with recessive parent is shown below



Such a cross is useful to determine the genotype of an unknown trait, *i.e.,* whether it is heterozygous or homozygous dominant for the trait.

Q. 2 Do you think Mendel's Laws of inheritance would have been different in the characters that he chose were located on the same chromosome.

Ans. If the characters are present on the same chromosome they would not assort independently as they are linked on the same chromosome. Percentage of linkage depends on the distance between the genes. With linkage no conclusive laws can be drown.

Q. 3 Enlist the steps of controlled cross-pollination. Would emasculation be needed in a cucurbit plant? Give reasons for your answer.

Thinking Process

Controlled cross-pollination is one of the major approaches of crop improvement programme. In such experiments it is important to make sure that only the desired pollen grains are used for pollination and the stigma is protected from contamination (from unwanted pollen).

Ans. *Steps of controlled cross-pollination are*

(i) Selection of parents with desired characters.

(ii) Emasculation, *i.e.*, if the female parent bears bisexual flowers, before dehiscence anther should be removed by forceps.

(iii) Bagging, *i.e.,* emasculated flowers have to be covered with a bag of suitable size, generally made up of butter paper, to prevent contamination of its stigma with unwanted pollen.

(iv) When the stigma of bagged flower attains receptivity, mature pollen grains collected from anthers of the male parent are dusted on the stigma

(v) The flowers are rebagged and the fruits are allowed to develop.

Emasculation is not always needed in a cucurbit plant. Emasculation is essential only in case of bisexual flowers to prevent self-pollination. In case of cucurbit plant, female parent produces usually unisexual flowers but may sometimes have bisexual flowers.

Note *If the female parent produces unisexual flowers, there is no need for emasculation. The female flower buds are bagged before the flowers open. When the stigma becomes receptive, pollination is carried out using the desired pollen and the flower rebagged.*

Q. 4 A person has to perform crosses for the purpose of studying inheritance of a few traits/characters. What should be the criteria for selecting the organisms?

Ans. *The criteria for selecting the organism to study inheritance are*

(i) Easily visible and different traits

(ii) Short life span

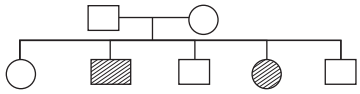
(iii) Simple pollination procedure

(iv) Organisms must be true breeds

(v) Mating of gametes has to be random

(vi) Can be easily manipulated

Q. 5 The pedigree chart given below shows a particular trait which is absent in parents but present in the next generation irrespective of sexes. Draw your conclusion on the basis of the pedigree.



Ans. The pedigree chart shows that the trait is autosome linked and recessive in nature. But, the parents are carriers (*i.e.,* heterozygous) hence, among the offsprings only few show the trait irrespective of sex. The other offsprings are either normal or carrier.

Q. 6 In order to obtain the F_1-generation Mendel pollinated a pure-breeding tall plant with a pure-breeding dwarf plant. But for getting the F_2-generation, he simply self-pollinated the tall F_1 plants. Why?

Ans. Characters segregate during gamete formation. Pure-breeding parents give rise to F_1 with heterozygous conditions. Only self-pollination of heterozygotes can result in all possible recombinations of characters in progeny as mating is random.

Q. 7 'Genes contain the information that is required to express a particular trait.' Explain.

Ans. Genes contain the information required to express a particular trait can be explained by the following experiment.

G Beadle and **E Tatum** set an experiment to prove that one gene possess a particular trait and is responsible for the production of one enzyme or protein. They performed their experiment on *Neurospora crassa* which were nutritionally mutant.

It was proved that a single protein contains several polypeptide and each polypeptide is controlled by separate gene. Thus, each gene expresses a particular trait. This theory was called one-gane-one enzyme or one gene-one polypeptide hypothesis.

But after the discovery of cistron (the functional unit of gene), the theory was named as one-cistron-one polypeptide hypothesis.

Q. 8 How are alleles of particular gene differ from each other? Explain its significance.

Ans. Alleles are polymorphs that differ in their nucleotide sequence resulting in contrasting phenotype expression. Alleles are the alternative forms of a same gene for, *e.g.,* genes for height have two allele, one for dwarfness (t) and one for tallness (T).

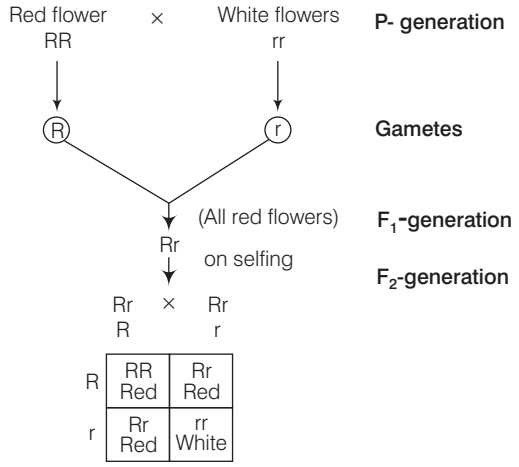
Significance

(i) A character may have two or more contrasting phenotypic expression, thus resulting variation in the population.

(ii) These are used in the studies of inheritance and in understanding their behaviour.

Q. 9 In a monohybrid cross of plants with red and white flowered plants. Mendel got only red flowered plants. On self-pollinating these F_1 plants got both red and white flowered plants in 3:1 ratio. Explain the basis of using RR and rr symbols to represent the genotype of plants of parental generation.

Ans.



Phenotypic ratio Red flower : White flower 3 : 1
Genotype ratio RR : Rr : rr 1 : 2 : 1

Generally, upper case letters are used as symbols for dominant and lower case for recessive traits of the same gene (alleles). Experiment shows that it is a monohybrid cross with 3 : 1 ratio in F_2-generation.

This shows parents must be true-breeds. As parents are diploid and homologous chromosomes carry alleles with similar type they are represented with RR and rr.

Q. 10 For the expression of traits genes provide only the potentiality and the environment provides the opportunity. Comment on the veracity of the statement.

Thinking Process

Phenotype = Genotype + Environment
(Trait) (potentiality) (opportunity)

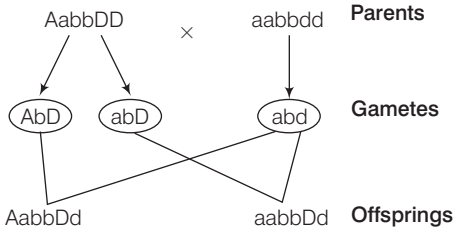
Ans. Obviously, genes are not the only factors that determine phenotype. Environment also plays an important role in the expression of traits. Genes are actually quite active throughout our lives, switching their expression on and off in response to the environment.

Besides the effect of internal factors like hormones and metabolism on gene expression, external factors like temperature, light, nutrition, etc., also affect the gene expression and ultimately exhibiting phenotypic changes.

So, we can say that genes provide only the potentiality and the environment provides the opportunity for the expression of traits.

Q. 11 A, B, D are three independently assorting genes with their recessive alleles a, b, d, respectively. A cross was made between individuals of Aa bb DD genotype with aa bb dd. Find out the type of genotypes of the offspring produced.

Ans. The given cross Aa bb DD X aa bb dd, is a trihybrid cross, Accordingly the type of offspring produced would be,



Q. 12 In our society a woman is often blamed for not bearing male child. Do you think it is right? Justify.

Thinking Process

The sex determining chromosome in case of humans is of XY type.

Ans. It is unfortunate that in our society women are blamed for giving birth to female children and have been ostracised and ill-treated because of this false notion. Out of 23 pairs of chromosomes present, 22 pairs are exactly same in both males and females, these are the autosomes.

A pair of X-chromosomes are present in the female, whereas the presence of an X and Y-chromosome are determinant of the male characteristic. During spermatogenesis among males, two types of gametes are produced.

50 per cent of the total sperm produced carry the X-chromosome and the rest 50% has Y-chromosome besides the autosomes. Females, however, produce only one type of ovum with an X-chromosome. There is an equal probability of fertilisation of the ovum with the sperm carrying either X or Y-chromosome.

In case when the ovum fertilises with a sperm carrying X-chromosome the zygote develops into a female (XX) and the fertilisation of ovum with Y-chromosome carrying sperm results into a male offspring. Thus, it is evident that it is the genetic makeup of the sperm (male) that determines the sex of the child.

It is also evident that in each pregnancy there is always 50% probability of having either a male or a female child.

Q. 13 Discuss the genetic basis of wrinkled phenotype of pea seed.

Ans. Seed shape is determined by a single gene, with the allele (R) for round peas dominant over the allele (r) for wrinkled peas (recessive trait).

It the alleles for the gene controlling the seed shape are homozygous in a plant, it will show the character or phenotype of same alleles, *i.e.,*-RR- round seed, rr-wrinkled seed.

On the other hand, if the alleles of gene are heterozygous. They will express the phenotype of dominant allele.

Rr - Round seed (r- wrinkled is recessive)
This is the genetic basis of wrinkled phenotype of pea seed.

Q. 14 Even if a character shows multiple allelism, an individual will only have two alleles for that character. Why?

Ans. Multiple alleles are the multiple forms of a gene which occur on the same gene locus, but distributed in different organisms in the gene pool with an organism, which carry only two alleles and the gamete have only one allele.

Despite multiple allelism, an individual will have only two alleles because an individual develops from a zygote which is the result of fusion of sperm (carrying father set of (*n*)haploid chromosomes) and an egg (carrying mother set of haploid chromosomes).

Sperm and an egg have only one gene (allele) for each trait. A zygote when becomes diploid, have two alleles for each trait. It is the maximum number of alleles an individual can have. *e.g.,* genes of blood groups.

Q. 15 How does a mutagen induce mutation? Explain with example.

Ans. Mutagens may be physical, *i.e.,* ionising radiations X-ray,UV rays, gamma rays, DNA reactive chemicals, *i.e.,* hydroxyl radicals, H_2O_2, etc., or biological such as virus.
A mutagen can induce mutation by inducing, a change in the base sequence by insertion, deletion or substitution.

e.g., a single base sequence substitution at the sixth codon of the β-globin gene changes the codon from GAG to GUG. This results in the substitution of glutamic acid (Glu) by valine (Val) at the sixth position of the β-globin chain of the haemoglobin molecule.

The mutant haemoglobin molecule undergoes polymerisation under low oxygen tension causing the change in the shape of the RBC from biconcave disc to the elongated sickle, *i.e.*, like structure which is not functional.

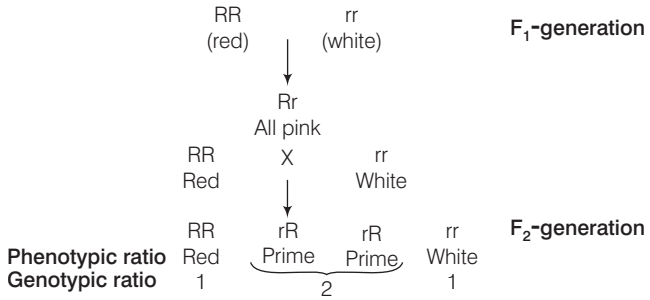
Short Answer Type Questions

Q. 1 In a Mendelian monohybrid cross, the F_2-generation shows identical genotypic and phenotypic ratios. What does it tell us about the nature of alleles involved? Justify your answer.

Thinking Process

In a monohybrid cross starting with parents which are homozygous dominant and homozygous recessive, F_1 would be heterozygous for the trait and would express the dominant allele. But in case of incomplete dominance the result will be different.

Ans. In case of incomplete dominance, a monohybrid cross shows the result as follows



Here, the phenotypic and genotypic both ratios are the same. So, we can conclude that when genotypic and phenotypic ratios are the same, alleles show incomplete dominance. *i.e.,* none of the two alleles shows dominance thus producing hybrid intermediate from the expression of two homozygous alleles.

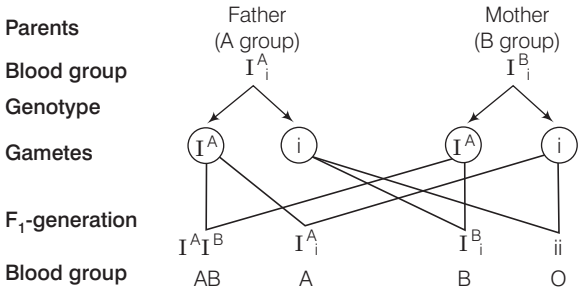
Q. 2 Can a child have blood group 'O' if his parents have blood group 'A' and 'B' Explain.

Thinking Process

The child with blood group O will have homozygous recessive alleles. Therefore, both the parents should be heterozygous, i.e., genotype of father will be $I^A i$, *or* $I^B i$ *and of mother will be* $I^A i$ *or* $I^B i$.

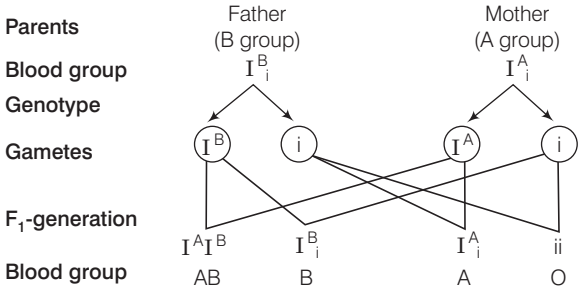
Ans. A child have blood group O in the following two cases

Case I When father is $I^A i$ and mother is $I^B i$.



The offsprings will have the above possible blood groups. *i.e.,* AB, A, B and O

Case II When father is $I^B i$ and mother is $I^A i$.



The offsprings will have the above possible blood groups, *i.e.,* AB, A, B and O. Thus, a child can have blood group 'O' if parents have heterozygous alleles for group 'A' and 'B'.

Q. 3 What is Down's syndrome? Give its symptoms and cause. Why is it that the chances of having a child with Down's syndrome increases if the age of the mother exceeds forty years?

Ans. Down's syndrome is a human genetic disorder caused due to trisomy of chromosome number 21. Such individuals are aneuploid and have 41 chromosomes, *i.e.,* $(2n+1)$

Symptoms of down's syndrome are

(i) Mental retardation

(ii) Growth abnormalities

(iii) Constantly open mouth

(iv) Dwarfness, etc., gonads and genitalia under developed

The reason for the disorder is the non-disjunction (failure to separate) of homologous chromosome (a pair 21 during meiotic division. The chances of having a child with Down's syndrome increases with the age of the mother (+40) because age adversely affects meiotic chromosome behaviour.

Meiosis in the egg cells is not completed, until after fertilisation. During this long gap (till meiosis is not completed) egg cells are arrested in prophase I and chromosomes are unpaired. The greater the time they remain upaired greater the chance for unpairing and chromosome non-disjunction.

Q. 4 How was it concluded that genes are located on chromosomes?

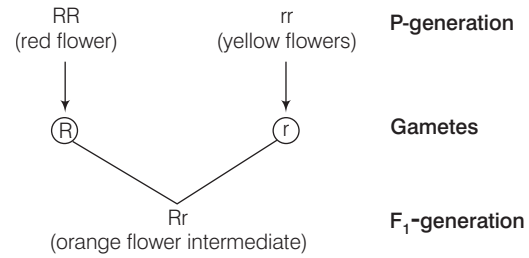
Ans. Chromosome theory of inheritance was proposed by **Sutton** and **Boveri** independently in 1902. The theory believes that chromosomes are vehicles of heriditary information, possess Mendelian factors or genes and it is the chromosomes which segregate and assort independently during transmission from one generation to the next.

Q. 5 A plant with red flowers was crossed with another plant with yellow flowers. If F1 showed all flowers orange in colour, explain the inheritance.

Thinking Process

If any of the alleles does not fully dominate in a heterozygous condition, it is called incomplete dominance.

Ans. Incomplete dominance is the phenomenon where neither of the two alleles shows dominance thus producing intermediate hybrid between the expression of two alleles in homozygous state. In this case, a new phenotype in between the two original phenotype appears.



Q. 6 What are the characteristic features of a true-breeding line?

Ans. True breeding is a stable trait inheritance and expression for several generations as a result of continuous self-pollination.

Characteristic features of a true-breeding line

(i) They are used as parents in artificial hybridisation as they provide gametes with all similar traits.

(ii) Homozygous recessive plants are used in test cross to determine the genotype.

Q. 7 In peas,tallness is dominant over dwarfness, and red colour of flowers is dominant over the white colour. When a tall plant bearing red flowers was pollinated with a dwarf plant bearing white flowers, the different phenotypic groups were obtained in the progeny in numbers mentioned against them

Tall, Red = 138
Tall, White = 132
Dwarf, Red = 136
Dwarf, White = 128

Mention the genotypes of the two parents and of the four offspring types.

Ans. The result shows that the four types of offspring are in a ratio of 1:1:1:1. Such a result is observed in a test cross progeny of a dihybrid cross.

The cross can be represented as

Parents Tall and red (TtRr) × Dwarf and white (ttrr)

Offsprings

♀ \ ♂	**TR**	**Tr**	**tR**	**tr**
tr	TtRr (tall and red)	Ttrr (tall and white)	ttRr (dwarf and red)	ttrr (dwarf and white)

Q. 8 Why is the frequency of red-green colourblindness is many times higher in males than that in the females?

Ans. Colourblindness is a X-inked sex inheritance. For becoming colourblind, the female must have the allele for it in both her X-chromosomes and if only one X-chromosome of female possess allele for colour blind character she becomes the carrier for this characteristics But males develop colourblindness when their sole X- chromosome has the allele for it. Thus males are more prone to colour blindness while females are carriers.

Q. 9 If a father and son are both defective in red-green colour vision, is it likely that the son inherited the trait from his father? Comment.

Ans. Gene for colourblindness is X-chromosome linked, and sons receive their sole X-chromosome from their mother, not from their father. Male to male inheritances is not possible for X-linked traits in humans.

In the given case the mother of the son must be a carrier (heterozygous) for colour blindness gene, thus transmitting the gene to her son.

Q. 10 Discuss why *Drosophila* has been used extensively for genetical studies?

Ans. **Morgan** worked with the tiny fruit flies, *Drosophila melanogaster*, which were found to be suitable for genetical studies due to the following characteristics

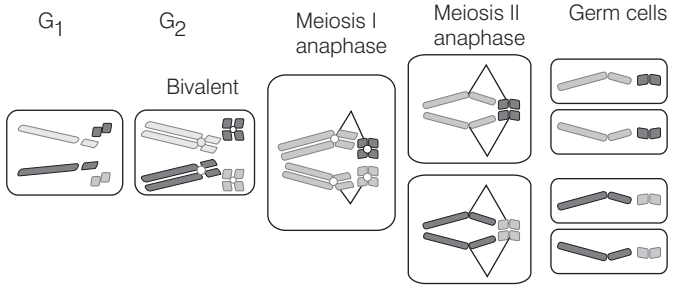
(i) They could be grown on simple synthetic medium in the laboratory.
(ii) They complete their life-cycle in about two weeks.
(iii) A single mating could produce a large number of progeny flies.
(iv) A clear differentiation of the sexes– the male and female flies are easily distinguishable.
(v) It has many types of variations (hereditary) that can be seen with low power microscopes.

Q. 11 How do genes and chromosomes share similarity from the point of view of genetical studies?

Ans. By 1902, the chromosome movement during meiosis had been worked out.

Walter Sutton and **Theodore Boveri**, (1902) noted that the behaviour of chromosomes was parallel to the behaviour of genes and used chromosome movement to explain Mendel's Laws.

They studied the behaviour of chromosomes during mitosis (equational division) and during meiosis (reduction division). The chromosomes as well as genes occur in pairs and the two alleles of a gene pair are located of homologous sites of homologous chromosomes.



Chromosome movement in meiosis and germ cell formation in a cell with four chromosomes. Chromosomes segregate when germ cells are formed

Q. 12 What is recombination? Discuss the applications of recombination from the point of view of genetic engineering.

Ans. Recombination refers to the generation of new combination of genes which is different from the parental types. It is produced due to crossing over that occurs during meiosis prior to gamete formation.

Applications of Recombination

(i) It is a means of introducing new combinations of genes and hence new traits.

(ii) It increases variability which is useful for natural selection and under changed environment.

(iii) Since, the frequency of crossing over depends upon the distance between the two genes, the phenomenon is used for preparing linkage chromosome maps.

(iv) It has proved that genes lie in a linear fashion in the chromosome.

(v) Breeders have to select small or large population for obtaining the required cross-overs. For obtaining cross-overs between closely linked genes, a very large population is required.

(vi) Useful recombinations produced by crossing over are picked up by breeders to produce useful new varieties of crop plants and animals. Green revolution has been achieved in India due to this selective picking up of useful recombinations. Operation flood or white revolution is also being carried out on the similar lines.

Q. 13 What is artificial selection? Do you think it affects the process of natural selection? How?

Ans. Artificial selection (or selective breeding) describes intentional breeding for certain traits or combination of traits by humans, for exploiting the variations existing among species. It is of three types-mass selection, pure-line selection and clonal selection.

Yes, it affects the process of natural selection. Natural selection selects for/or against traits based on their effect on the fitness of the organism. In artificial selection, traits are selected based on human preference for improving traits.

The process of natural selection leads to evolutionary change in the expression of the trait in the population, whereas the artificial selection, though being the same process, involves the traits preferred by humans for its own benefit. It is a much faster process than the natural selection but it may impose threat on diversity in long run making it unfit to the environment.

Q. 14 With the help of an example differntiate between incomplete dominance and co-dominance.

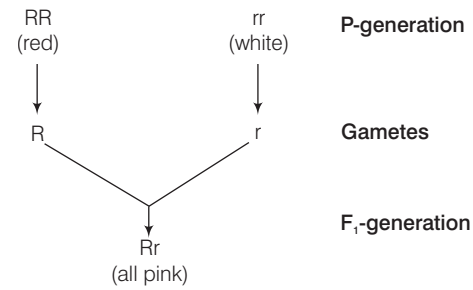
Ans. Incomplete dominance is a phenomenon where two contrasting alleles are present together but neither of the alleles is dominant over other and the phenotype formed is intermediate of the two alleles.

e.g., the kind of inheritance in the dog flower (Snapdragon or *Antirrhinum* species) in which the intermediate trait is expressed in F_1-generation.

Codominance is a phenomenon in which when two contrasting alleles are present together and both of the alleles express themselves.

e.g., AB blood group in humans where both the alleles are expressed to produce RBC surface antigens A and B.

(i) **Coss showing incomplete dominance**



(ii) **Blood group showing co-dominance**

Genotype	Surface Antigen	Blood Group
I^Ai (dominance)	A	A
I^AI^A	A	A
I^Bi (dominance)	B	B
I^BI^B	B	B
I^AI^B (co-dominance)	AB	AB
ii	—	O

Q. 15 It is said, that the harmful alleles get eliminated from population over a period of time, yet sickle-cell anaemia is persisting in human population. Why?

Ans. Sickle-cell anaemia is an autosomal recessive disease caused by haemoglobins an oxygen carrying protein in blood cells.

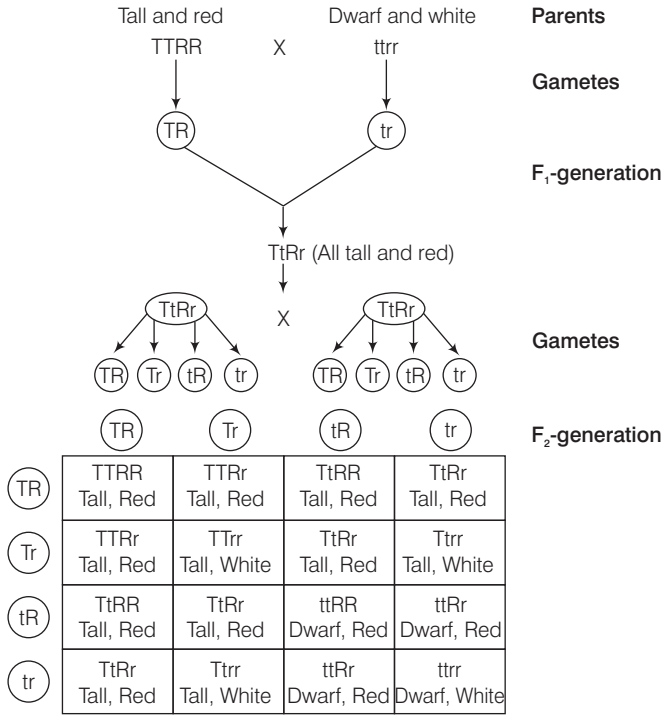
Despite the disease's lethal symptoms, it protects the carrier from malaria. Its allele are most common in the people of African descent (about 7% people of African descent carry an allele) and some other are as where malaria in prevalent.

It provides the vital protection from malaria. Individuals with HbAS heterozygotes tend to survive better than individuals with HbSS (homozygotes) as they are not exposed to the same severity of risk.

Long Answer Type Questions

Q. 1 In a plant tallness is dominant over dwarfness and red flower is dominant over white. Starting with the parents work out a dihybrid cross. What is standard dihybrid ratio? Do you think the values would deviate if the two genes in question are interacting with each other?

Ans.



	TR	Tr	tR	tr
TR	TTRR Tall, Red	TTRr Tall, Red	TtRR Tall, Red	TtRr Tall, Red
Tr	TTRr Tall, Red	TTrr Tall, White	TtRr Tall, Red	Ttrr Tall, White
tR	TtRR Tall, Red	TtRr Tall, Red	ttRR Dwarf, Red	ttRr Dwarf, Red
tr	TtRr Tall, Red	Ttrr Tall, White	ttRr Dwarf, Red	ttrr Dwarf, White

The standard dihybrid ratio is 9:3:3:1. Yes, the values will show deviation if the two genes in the above case are interacting with each other. When the genes are linked, they do not assort independently but remain together in the gametes and the offsprings, give a dihybrid ratio of 3:1 and show a test cross ratio of 1:1 instead of 1:1:1:1.

Q. 2 (a) In humans, males are heterogametic and females are homogametic, Explain. Are there any examples where males are homogametic and females heterogametic?

(b) Also describe as to, who deterrmines the sex of an unborn child? Mention whether temperature has a role in sex determination.

Ans. **(a)** The term homogametic and heterogametic refers to the organism depending upon whether all the gametes contain one type of sex chromosome (*homo* same) or two different types of sex chromosomes (*hetero* different).

Humans show XX/XY type of sex determination, *i.e.,* females contain 2 copies of X-chromosome and males contain 1 X and 1 Y-chromosome. Therefore, ova produced by females contain the same sex chromosome, *i.e.,* X.

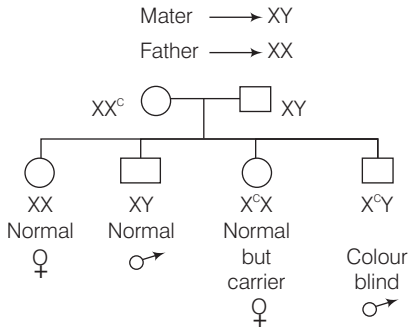
On the other hand the sperms contain 2 different types of chromosomes, *i.e.,* 50% sperms have X and 50% have Y-chromosomes (meiosis). Therefore, the sperms are different with respect to the composition of sex chromosome.

In case of humans, females are considered to be homogametic while males are heterogametic. Yes, there are examples where males are homogametic and females are heterogametic. In some birds the mode of sex determination is denoted by ZZ (males) and ZW (females). Certain moths and butterflies also show homogametic males and heterogametic females.

(b) As a rule the heterogametic organism determines the sex of the unborn child. In case of humans, since males are heterogametic it is the father and not the mother who decides the sex of the child. In some animals like crocodiles, lower temperature favour hatching of female offsprings and higher temperatures lead to hatching of male offsprings.

Q. 3 A normal visioned woman, whose father is colour blind, marries a normal visioned man. What would be probability of her sons and daughters to be colour blind? Explain with the help of a pedigree chart.

Ans. *The genotype of parents are*



50% daughters are normal visioned but 50% will be carries and 50% of sons are likely to be colour blind and 50% are normal visioned.

Q. 4 Discuss in detail the contributions of Morgan and Sturvant in the area of genetics.

Ans. **T H Morgan** (1866-1945) was given the Nobel Prize in 1933.

His contributions are

(i) Morgan worked on fruit fly *Drosophila melanogaster* and proposed the chromosomal theory of linkage.

(ii) He stated and established that genes are located on the chromosome.

(iii) He established the principle of linkage, crossing over, sex-linked inheritance and discovered the relation between gene and chromosome.

(iv) He established the technique of chromosome mapping.

(v) He observed and worked on mutation.

Alfred Henry Sturtevant (1891-1970) student of morgan was given the National Medal of Science in 1967. *His contributions are*

(i) He constructed the first genetic map of a chromosome while working on the *Drosophila* genome.

(ii) His main contributions to science include his analysis of genetic 'linkage groups,' which became classical method of chromosome mapping that is still used today. In 1913, he determined that genes were arranged on chromosomes in a linear fashion, like beads on a necklace. He also showed that the gene for any specific trait was in a fixed location (locus).

(iii) His work on *Drosophila* proved that two closely related species showed newly recurring mutations that were allelic and thus probably identical. His work also helped to determine genetic role in sexual selection and development and displayed the importance of chromosomal crossing over in mutations.

(iv) One of Sturtevant's principal contributions was his introduction to the concept that the frequency of crossing over between two genes could help to determine their proximity on a linear genetic map. His experiments determined that the frequency of double crossing over can be used to deduce gene order.

Q. 5 Define aneuploidy. How is it different from polyploidy? Describe the individuals having following chromosomal abnormalities.

(a) Trisomy of 21st Chromosome (b) XXY (c) XO

Ans. Aneuploidy is a phenomenon which occurs due to non-disjunction, resulting in gain or loss of one or more chromosomes during meiosis.

Aneuploidy is different from polyploidy. Polyploidy is a phenomenon in which the organisms contain more than two monoploid value or basic sets of chromosomes. *i.e.,* –3*n*, 4*n*etc. Example of such organisms are certain fish and salamanders and is commonly found in plants like grapes, banana.

Chromosomal Abnormalities

(a) Down's syndrome is an autosomal disorder that is caused by the trisomy of chromosome 21.

The individual is short statured with round head, open mouth, protruding tongue, short neck, slanting eyes, and broad short hands. The individual also shows retarded mental and physical growth,under developed gonads and genitats, etc.

(b) Klinefelter's syndrome is the chromosomal disorder that is caused by the presence of an additional copy of X-chromosome resulting in the karyotype 45+XXY.

In this disorder sex of the individual is masculine but possess feminine characters also. The individual shows gynaecomastia, *i.e.,* development of breasts. The individual will be often sterile having poor beard growth and feminine pitched voice.

(c) Turner's syndrome is the chromosomal disorder that is caused by the absence of one of the X-chromosomes, resulting in the karyotype 45+XO.

In this disorder the individual (female) will be sterile with rudimentary ovaries. Other symptoms include shield-shaped thorax, webbed neck, poor development of breasts, short stature, small uterus and puffy fingers.

6

Molecular Basis of Inheritance

Multiple Choice Questions (MCQs)

Q. 1 In a DNA strand the nucleotides are linked together by

(a) glycosidic bonds (b) phosphodiester bonds
(c) peptide bonds (d) hydrogen bonds

Ans. ***(b)*** (In a DNA strand the nucleotides are linked together by 3′–5′ phosphodiester linkage (bonds) to form a dinucleotide. More nucleotides can be joined in such a manner to form a polynucleotide chain.

Q. 2 A nucleoside differs from a nucleotide. It lacks the

(a) base (b) sugar
(c) phosphate group (d) hydroxyl group

Ans. ***(c)*** A nitrogenous base is attached to the pentose sugar by an N-glycosidic linkage to form a nucleoside, *i.e.,* Nucleoside=Nitrogen base+Pentose sugar.

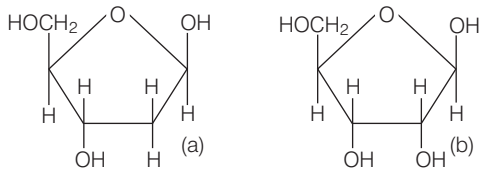
When a phosphate group is attached to the 5′-OH of a nucleoside through phosphodiester linkage, a nucleotide is formed, *i.e.,* Nucleotide = Nitrogen base + Pentose sugar + Phosphate (PO_4).

So, a nucleoside differs from a nucleotide as it lacks the phosphate group.

Q. 3 Both deoxyribose and ribose belong to a class of sugars called

(a) trioses (b) hexoses (c) pentoses (d) polysaccharides

Ans. ***(c)*** Both deoxyribose and ribose belong to the class pentoses as it contains 'S' carbon atoms.



Structure of (a) deoxyribose (b) ribose sugar

Q. 4 The fact that a purine always paired base through hydrogen bonds with a pyrimidine base leads to, in the DNA double helix

(a) the antiparallel nature
(b) the semiconservative nature
(c) uniform width throughout DNA
(d) uniform length in all DNA

Ans. *(c)* The diameter of the strand is always constant due to a pairing of purine (adenine and guanine) and pyrimidine (cytosine and thymine). This specific bonding gives uniform width to the DNA.

Q. 5 The net electric charge on DNA and histones is

(a) both positive
(b) both negative
(c) Both (a) and (b)
(d) zero

Ans. *(c)* DNA consists of a nitrogenous base, pentose sugar and a phosphate group. DNA has negative charge due to the presence of phosphate group (PO_4^{3-}).

Histones are rich in the basic amino acid residues lysines and arginines, which carry positive charges in their side chains. Therefore, histones are positively charged.

Q. 6 The promoter site and the terminator site for transcription are located at

(a) 3′ (downstream) end and 5′ (upstream) end, respectively of the transcription unit
(b) 5′ (upstream) end and 3′ (downstream) end, respectively of the transcription unit
(c) the 5′ (upstream) end
(d) the 3′ (downstream) end

Ans. *(c)* The promoter is the binding site for RNA polymerase for initiation of transcription.

The promoter is located towards 5′-end (upstream) of the structural gene of coding strands and provides the binding site for RNA polymerase.

Q. 7 Which of the following statements is the most appropriate for sickle-cell anaemia?

(a) It cannot be treated with iron supplements
(b) It is a molecular disease
(c) It confers resistance to acquiring malaria
(d) All of the above

Ans. *(d)* Sickle-cell anaemia is an autosome linked recessive trait. In this genetic disorder point mutation in β-globin chain results in change of glutamate (glutamic acid) to valine at sixth position. Only the homozygous individuals for $Hb^S{}_2$, *i.e.,* Hb^SHb^S show the diseased phenotype. The heterozygous individuals (Hb^S/Hb^A) are carriers.

It is also known that heterozygotes, having both types of haemoglobin, show resistance to malaria infection because the body targets the *P. falciparum* (protozoan) infected cells for destruction of RBC.

Q. 8 One of the following is true with respect to AUG

(a) it codes for methionine only
(b) it is also an initiation codon
(c) it codes for methionine in both prokaryotes and eukaryotes
(d) All of the above

Thinking Process

Three adjacent nitrogenous bases constitute a codon which specifies the placement of one amino acid in a polypeptide.

Ans. ***(d)*** Polypeptide synthesis is signalled by two initiation codons commonly AUG or methionine codon and rarely GUG or valine codon. Since there are 64 triplet codons and only 20 amino acids, the incorporation of some amino acids must be influenced by more than one codon.

Only tryptophan (UGG) and methionine (AUG) are specified by single codons. AUG codes for methionine in both prokaryotes and eukaryotes.

Q. 9 The first genetic material could be

(a) protein (b) carbohydrates (c) DNA (d) RNA

Ans. ***(d)*** RNA was the first genetic material. There is now enough evidence to suggest that essential life processes (such as metabolism, translation, splicing, etc.), evolved around RNA.

RNA used to act as a genetic material as well as a catalyst (there are some important biochemical reactions in living systems that are catalysed by RNA catalysts and not by protein enzymes). But, RNA being a catalyst was reactive and hence unstable.

Therefore, DNA has evolved from RNA with chemical modifications that make it more stable. DNA being double-stranded and having complementary strand further resists changes by evolving a process of repair.

Q. 10 With regard to mature *m*RNA in eukaryotes

(a) exons and introns do not appear in the mature RNA
(b) exons appear but introns do not appear in the mature RNA
(c) introns appear but exons do not appear in the mature RNA
(d) both exons and introns appear in the mature RNA

Ans. ***(b)*** In eukaryotes, the monocistronic structural genes have interrupted coding sequences *i.e.,* the genes in eukaryotes are split. The coding sequences or expressed sequences are defined as exons.

These sequences (exons) appear in mature or processed RNA. The exons are interrupted by introns or intervening sequences which do not appear in mature or processed RNA.

Q. 11 The human chromosome with the highest and least number of genes in them are respectively

(a) chromosome 21 and Y (b) chromosome 1 and X
(c) chromosome 1 and Y (d) chromosome X and Y

Ans. ***(c)*** In humans, chromosome 1 has highest genes (2968 approx.) and the Y has the fewest (231 approx.) genes.

Q. 12 Who amongst the following scientists had no contribution in the development of the double helix model for the structure of DNA?

(a) Rosalind Franklin (b) Maurice Wilkins
(c) Erwin Chargaff (d) Meselson and Stahl

Ans. ***(d)*** It was only in 1953 that **James Watson** and **Francis Crick**, based on the *X*-ray diffraction data produced by **Maurice Wilkins** and **Rasalind Franklin**, proposed a very simple but famous double helix model for the structure of DNA.

Erwin Chargaff observed that for a double-stranded DNA, the ratios between adenine and thymine and guanine and cytosine are constant and equals one.

On the other bond **Matthew Meselson** and **Franklin Stahl** in 1958 performed experiments on *E.coli* to prove that DNA replication is semi-conservative. But had no contribution it the development of double helix model.

Q. 13 DNA is a polymer of nucleotides which are linked to each other by 3′–5′ phosphodiester bond. To prevent polymerisation of nucleotides, which of the following modifications would you choose?

(a) Replace purine with pyrimindines
(b) Remove/Replace 3′ OH group in deoxy ribose
(c) Remove/Replace 2′ OH group with some other group in deoxy ribose
(d) Both (b) and (c)

Ans. ***(b)*** The enzyme called DNA polymerase progressively adds deoxyribonucleotides to the free 3′-end of the growing polynucleotide chain so, that replication of the 3′–5′ strand of the DNA molecule is continuous (growth of the new strand in 5′ → 3′ direction).

So, to prevent polymerisation of nucleotides 3′ OH group in deoxyribose should be replaced/removed.

Q. 14 Discontinuous synthesis of DNA occurs in one strand, because

(a) DNA molecule being synthesised is very long
(b) DNA dependent DNA polymerase catalyses polymerisation only in one direction (5′→ 3′)
(c) it is a more efficient process
(d) DNA ligase has to have a role

Thinking Process

The replication of 3′ → 5′ strand is continuous and it is called leading strand, while the replication of second strand (5′→ 3′ strand) of the DNA molecules is discontinuous and it is known as the lagging strand.

Ans. ***(b)*** DNA polymerase adds deoxyribonucleotides to the free 3′-end of the growing polynucleotide chain so, that replication of the 3′→ 5′ strand of the DNA molecule is continuous (growth of the new strand in 5′ → 3′ direction).

Since, DNA dependent DNA polymerase catalyses polymerisation only in one direction (5′ → 3′), discontinuous synthesis of DNA occurs in the other strand.

Q. 15 Which of the following steps in transcription is catalysed by RNA polymerse?

(a) Initiation (b) Elongation (c) Termination (d) All of these

Ans. ***(b)*** The DNA dependent RNA polymerase helps in DNA replication by catalysing the polymerisation in only one direction, *i.e.,* 5′ → 3′.

Q. 16 Control of gene expression takes place at the level of

(a) DNA-replication (b) transcription
(c) translation (d) None of these

Thinking Process

Regulation of gene expression refers to a very broad term that may occur at various levels.

Ans. ***(b)*** Considering that gene expression results in the formation of a polypeptide, it can be regulated at several levels. *In eukaryotes, the regulation could be exerted at*

(i) transcriptional level (formation of primary transcript)
(ii) processing level (regulation of splicing)
(iii) transport of *m*RNA from nucleus to the cytoplasm
(iv) translational level

While, in prokaryotes, control of the rate of transcriptional initiation is the predominant site for control of gene expression.

Q. 17 Regulatory proteins are the accessory proteins that interact with RNA polymerase and affect its role in transcription. Which of the following statements is correct about regulatory protein?

(a) They only increase expression
(b) They only decrease expression
(c) They interact with RNA polymerase but do not affect the expression
(d) They can act both as activators and as repressors

Thinking Process

Regulatory protein is a term used in genetics to describe a protein involved in regulating gene expressions. There are often needed to switch a gene on (activator) or to switch off a gene (represssor).

Ans. ***(d)*** Regulatory sequences (proteins) control the functions of structural genes and are at called regulatory genes. The important regulatory genes are promoters, terminators, operators and repressor.

To regulate the process of transcription, transcription factors (a sequence of specific DNA-binding factor) alone or with other proteins, promoter (as on activator) or stop as a repress or the binding site of RNA polymerase to DNA.

Q. 18 Which was the last human chromosome to be completely sequenced?

(a) Chromosome 1 (b) Chromosome 11
(c) Chromosome 21 (d) Chromosome-X

Ans. ***(a)*** Chromosome 1 was the last completed chromosome, sequenced two decades after the beginning of the human Genome Project (hGP). It is the designation for the largest human chromosome.

Q. 19 Which of the following are the functions of RNA?

(a) It is carrier of genetic information from DNA to ribosomes synthesising polypeptides
(b) It carries amino acids to ribosomes
(c) It is a constituent component of ribosomes
(d) All of the above

Thinking Process

RNA is a single chain polyribonucleotide which functions as carrier of coded genetic or hereditary information from DNA to cytoplasm for taking part in protein and enzyme synthesis.

Ans. ***(d)*** *r*RNA, *m*RNA and *t*RNA are major classes of RNAs that are involved in gene expression.

*r*RNAs bind protein molecules and give rise to ribosomes.

*m*RNA carries coded information for translation into polypeptide formation.

*t*RNA is called soluble or adaptor RNA and carries amino acids to *m*RNA during protein synthesis.

Q. 20 While analysing the DNA of an organism a total number of 5386 nucleotides were found out of which the proportion of different bases were Adenine = 29%, Guanine = 17%, Cytosine = 32%, Thymine = 17%. Considering the Chargaffs rule it can be concluded that

(a) it is a double-stranded circular DNA
(b) it is single-stranded DNA
(c) it is a double-stranded linear DNA
(d) No conclusion can be drawn

Ans. ***(b)*** According to Chargaff's rules of base pairing,

(i) The amount of adenine is always equal to the amount of thymine and the amount of guanine is always equal to the amount of cytosine.

(ii) Adenine is joined to thymine with two hydrogen bonds and guanine is joined to cytosine by three hydrogen bonds.

(iii) The ratio of adenine to thymine and that of guanine to cytosine is always equal to one,

i.e., $$\frac{A}{T} = \frac{G}{C} = 1$$

In the given organism, the DNA is not following the Chargaff's rule, hence it can be concluded that it is a single-stranded DNA, not double-stranded.

Q. 21 In some viruses, DNA is synthesised by using RNA as template. Such a DNA is called

(a) A-DNA (b) B-DNA (c) *c*DNA (d) *r*DNA

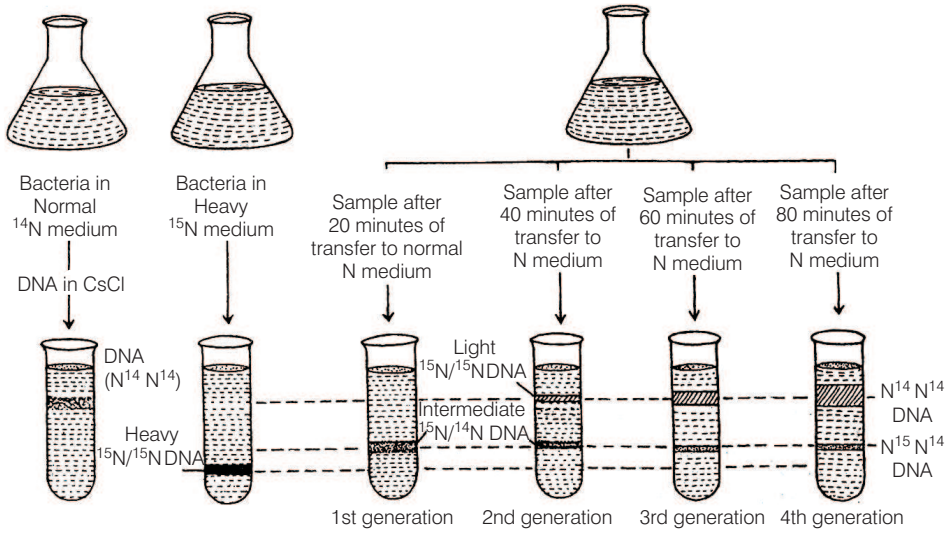
Ans. ***(c)*** In some viruses, like retroviruses (*e.g.,* HIV), an enzyme called reverse transcriptase is used to generate complementary DNA (*c*DNA) from an RNA template. This process is termed reverse transcription.

Q. 22 If Meselson and Stahl's experiment is continued for four generations in bacteria, the ratio of 15_N / 15_N : 15_N / 14_N : 14_N / 14_N containing DNA in the fourth generation would be

(a) 1:1:0 (b) 1:4:0 (c) 0:1:3 (d) 0:1:7

Ans. ***(d)*** Meselson and Stahl found that DNA of the first generation was hybrid or intermediate (^{15}N and ^{14}N). It settled in caesium chloride at a level higher than the fully labelled DNA of parent bacteria (^{15}N ^{15}N). The second generation of bacteria after 40 minutes, contained two types of DNA, 50% light (N^{14} N^{14}) and 50% intermediate (N^{15} N^{14}).

The third generation of bacteria after 60 minutes contained two types of DNA, 25% intermediate (N^{15} N^{14}) and 75% light (N^{14} N^{14}) in 1:3 ratio. The fourth generation after 80 minutes contained 12.5% N^{15} N^{14} and 87.5% N^{14} N^{14} DNA in 1:7 ratio.



Meselson and Stahl's experiment

Q. 23 If the sequence of nitrogen bases of the coding strand of DNA in a transcription unit is

5' - A T G A A T G - 3',

the sequence of bases in its RNA transcript would be

(a) 5′ - A U G A A U G - 3′ (b) 5′ - U A C U U A C - 3′
(c) 5′ - C A U U C A U - 3′ (d) 5′ - G U A A G U A - 3′

Ans. ***(a)*** 5′ - A T G A A T G - 3′ (coding strand)
↓
5′- T A C T T A C - 3′ (complementary strand)
↓
5′ -A U G A A U G - 3′ (RNA)

Q. 24 The RNA polymerase holoenzyme transcribes

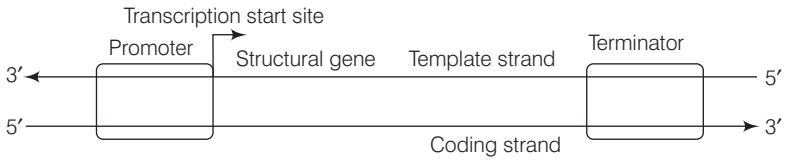
(a) the promoter, structural gene and the terminator region
(b) the promoter and the terminator region
(c) the structural gene and the terminator regions
(d) the structural gene only

Thinking Process

In prokaryotes, the structural gene is polycistronic and continuous. In bacteria (prokaryotes), the transcription of all the three types of RNA (mRNA, tRNA and rRNA) is catalysed by single DNA dependent enzyme, called the RNA polymerase.

Ans. ***(c)*** In *E. coli* bacterium, the RNA polymerase has co-factors β, β', α, α' and ω along with σ (sigma) factor, to catalyse the process. The transcription is completed in three steps.

Initiation σ (sigma) factor recognises the start signal and promotor region on DNA which then along with RNA polymerase binds to the promoter to initiate transcription.



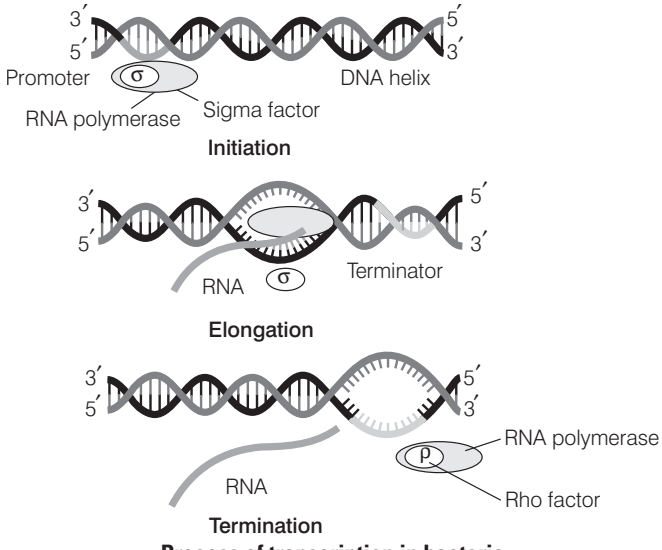
Schematic structure of a transcription unit

Elongation The RNA polymerase after initiation of RNA transcription loses the σ factor but continues the polymerisation of ribonucleotides to form RNA.

Termination Once the RNA polymerase reaches the termination region of DNA, the RNA polymerase is separated from DNA-RNA hybrid, as a result nascent RNA separates. This process is called termination which is facilitated by a termination factor ρ (rho).

In prokaryotes, *m*RNA does not require any processing, so both transcription and translation occur in the cytosol. It can be said that transcription and translation are coupled together.

Representation of initiation, elongation and termination are as given



Process of transcription in bacteria

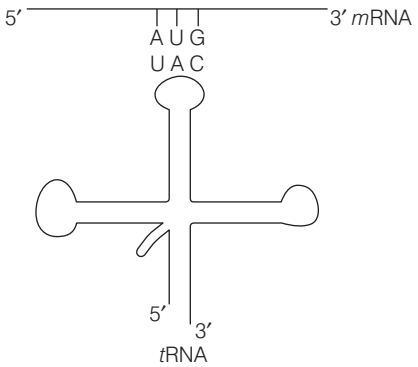
Q. 25 If the base sequence of a codon in *m*RNA is 5'-AUG-3', the sequence of *t*RNA pairing with it must be

(a) 5′ - UAC - 3′ (b) 5′ - CAU - 3′ (c) 5′ - AUG - 3′ (d) 5′ - GUA - 3′

Ans. ***(a)*** 5′ - A U G - 3′ (codon in *m*RNA)

| | |

5′ - U A C - 3′ (*t*RNA)



Q. 26 The amino acid attaches to the *t*RNA at its

(a) 5′-end (b) 3′-end (c) Anti codon site (d) DHU loop

Ans. ***(b)*** AA-binding site (amino acid binding site) lies at the 3′ end opposite the anticodon and has CCA-OH group. It is the site where amino acid attaches to the *t*RNA.

Q. 27 To initiate translation, the *m*RNA first binds to

(a) the smaller ribosomal sub-unit (b) the larger ribosomal sub-unit
(c) the whole ribosome (d) No such specificity exists

Thinking Process

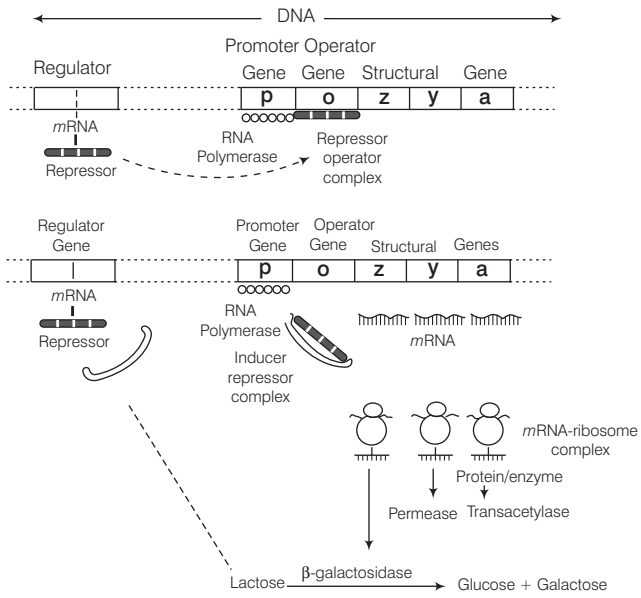
The cellular factory responsible for synthesising proteins is the ribosome.

Ans. ***(a)*** The ribosome consists of structural RNAs and about 80 different proteins. In its inactive state, it exist as two subunits, a large subunit and a small subunit. When the smaller subunit encounters the *m*RNA, the process of translation of the *m*RNA to protein begins .

Q. 28 In *E. coli*, the *lac* operon gets switched on when

(a) lactose is present and it binds to the repressor
(b) repressor binds to operator
(c) RNA polymerase binds to the operator
(d) lactose is present and it binds to RNA polymerase

Ans. ***(a)***



Jacob and Monod model of an inducible operon

In case of lactose presence

(i) Lactose acts as an inducer which binds to the repressor and forms an inactive repressor.
(ii) The repressor fails to bind to the operator region.
(iii) The RNA polymerase binds to the operator and transcript *lac m*RNA.
(iv) *lac m*RNA is polycistronic, *i.e.,* produces all three enzymes, β-galactosidase, permease and transacetylase.
(v) The *lac* operon is switched on.

In case of lactose absence

(i) When lactose is absent, *i* gene regulates and produces repressor *m*RNA which translate repression.
(ii) The repressor protein binds to the operator region of the operon and as a result prevents RNA polymerase to bind to the operon.
(iii) The operon is switched off.

Very Short Answers Type Questions

Q. 1 What is the function of histones in DNA packaging?

Ans. *Functions of histones in DNA packaging are*

(i) Histones as units of octamer participate in primary packaging of DNA.

(ii) Basic histone proteins neutralise the acidic DNA molecule.

Q. 2 Distinguish between heterochromatin and euchromatin. Which of the two is transcriptionally active?

Ans. Densely packed and dark stained chromatin regions are called hetorochromation, while, loosely packed light stained regions are called euchromatin.

Euchromation is transcriptionally active and is transcribed into *m*RNA. Due to very tight coiling heterochromatin can not be transcribed and is inert/inactive form.

Q. 3 The enzyme DNA polymerase in *E.coli* is a DNA dependent polymerase and also has the ability to proofread the DNA strand being synthesised Explain. Discuss the dual polymerase.

Ans. In bacteria, three types of DNA polymerases are there. All of them can add nucleotides in 5′→ 3′ direction. They process exonuclease activity as well. DNA polymerase III can proofread the newly synthesised strand and senses the wrong base insertions.

It deletes wrong bases and helps correct the mistake by putting in the right one, DNA polymerase. The only mistake it cannot corrects substitution of uracil in place of thymin.

It can repair any damages done to DNA by UV exposure, etc., or the left over proofreading mistakes. It detects mutation caused by UV, removes mismatched pairs and puts back the right ones.

Q. 4 What is the cause of discontinuous synthesis of DNA on one of the parental strands of DNA? What happens to these short stretches of synthesised DNA?

Ans. Synthesis of DNA always takes place in 5′→ 3′ direction. In a double stranded DNA both strands are anti parallel and complementary. During DNA synthesis as both strands act as templates, only one strand, *i.e.,* 3′→ 5′ can synthesis complementary strand in 5′→ 3′ direction.

The other strand, *i.e.,* 5′→ 3′ has to be synthesised in small stretches in opposite direction as replication fork moves to right. That is why DNA synthesis is discontinuous on one of the parental strands of DNA. These small stretches called Okazaki fragments are joined together by DNA ligase enzyme that closes the nicks.

Q. 5 Given below is the sequence of coding strand of DNA in a transcription unit 3′ AATGCAGCTAT TAGG-5′ write the sequence of

(a) its complementary strand

(b) the *m*RNA

Ans. According to base complementary rules,

(a) 5'TTACGTCGATAATCC-3' (b) 5'CGAUUAUCGACGUAA-3'

RNA uses the base uracil (U) rather than thymine (T). So, in RNA the base pairs are

Adenine (A) pairs with uracil (U)

Guanine (G) pairs with cytosine (C).

Q. 6 What is DNA polymorphism? What is it important to study it?

Ans. DNA polymorphism refers to the variation in DNA arising through mutation at non-coding sequences.

A special type of polymorphism, called VNTR (Variable Number of Tandem Repeats), is composed of repeated copies of a DNA sequence that lie adjacent to one another on the chromosome. Since, polymorphism is the basis of genetic mapping of human genome, therefore, it forms the basis of DNA fingerprinting too.

The single nucleotide polymorphisms are used in locating diseases and tracing of human history as well as in case of paternity testing.

Q. 7 Based on your understanding of genetic code, explain the formation of any abnormal haemoglobin molecule. What are the known consequences of such a change?

Thinking Process

It is the case of sickle-cell anaemia.

Ans. Due to point mutation in β-globin chain of haemoglobin molecule, glutamic acid (Glu) is replaced by valine (Val) at the sixth position.

Under stress condition erythrocytes lose their circular shape and become sickle-shaped. As a result, the cells cannot pass through narrow capillaries. Blood capillaries are clogged and thus affect blood supply to different organs.

Q. 8 Sometimes cattle or even human beings give birth to their young ones that are having extremely different sets of organs like limbs/position of eye(s) etc. Comment.

Ans. Sometimes cattle or even human beings give birth to their young ones that are having extremely different of organs like limbs/position of eye etc. It happens due to the disturbance in coordinated regulation of expression in sets of genes, which are associated with organ development.

Q. 9 In a nucleus, the number of ribonucleoside triphosphates is 10 times the number of deoxy *x* 10 ribonucleoside triphosphates, but only deoxy ribonucleotides are added during the DNA replication. Suggest a mechanism.

Ans. DNA polymerase enzyme is highly specific to recognise only deoxy ribonucleoside triphosphates. Therefore, it cannot hold RNA β-nucleotides.

Q. 10 Name a few enzymes involved in DNA replication other than DNA polymerase and ligase. Name the key functions for each of them.

Ans. The enzymes involved in DNA replication other than DNA polymerase and ligase are listed below with their functions.

(i) Helicase — Opens the helix

(ii) Topoisomerases — Removes the super coiling of DNA

(iii) Primase — Synthesises RNA primer

(iv) Telomerase — To synthesis the DNA of telomeric end of chromosomes.

Q. 11 Name any three viruses which have RNA as the genetic material.

Ans. In some viruses, RNA is the genetic material.
e.g., Tobacco mosaic viruscs, QB bacteriophage, HIV, influenza virus, etc.

Short Answer Type Questions

Q. 1 Define transformation in Griffith's experiment. Discuss how it helps in the identification of DNA as the genetic material.

Ans. In **Griffith's experiment**, transformation can be defined as a change in the genetic constitution of an organism by picking out up DNA from the environment (from dead organisms).

Transformation helps in identification of DNA as a genetic material. When heat was used to kill the virulent bacteria, they died but not their genetic material (DNA). This DNA when picked up by non-virulent bacteria made them capable of causing infection.

Since, ability to cause infection could be passed on by these organisms to their progeny, it was concluded that DNA was the material that was inherited.

Q. 2 Who revealed biochemical nature of the transforming principle?

Ans. Oswald, Avery, Colin MacLeod and Maclyn McCarty revealed biochemical nature of the transforming principle.

They reported **Griffith's experiment** in an *in vitro* system in order to determine biochemical nature of transforming principle.

They reported that DNA from the heat-killed S-type bacteria caused the transformation of non-virulent R-type bacteria into virulent S-type bacteria. They also discovered that proteases and RNase did not affect transformation while DNase inhibited the process. They concluded that DNA is the hereditary material.

Q. 3 Discuss the significance of heavy isotope of nitrogen in the Meselson and Stahl's experiment.

Thinking Process

Meselson *and* ***Stahl*** *used heavy isotope of* ^{15}N *in the nutrient medium to grow Escherichia coli (E. coli), for several generations.*

Ans. They performed experiments on *E. coli* to prove that DNA replication is semi-conservative. They first grew the bacteria in a medium containing $^{15}NH_4Cl$ (in which ^{15}N is the heavy istope of nitrogen) for many generations.

Then they transferred the cells into a medium with normal $^{14}NH_4Cl$ (in which ^{14}N is the lighter isotope) and took the samples at various definite time intervals as the cells multiplied. The extracted DNAs were centrifuged and measured to get their densities.

The DNA extracted from the culture after one generation of transfer from then ^{15}N mediun to ^{14}N mediun, (*i.e.,* after 20 minutes *E.coli* divides every 20 minutes) showed an intermediate hybrid density, *i.e.,* both heavy and light nitrogen, which proved the semi-conservative nature of DNA.

Q. 4 Define a cistron. Giving examples differentiate between monocistronic and polycistronic unit.

Ans. A cistron is stretch of base sequences that codes for one polypeptide chain including adjacent control regions. It may also code for a *t*RNA, *r*RNA molecule or may perform other specific functions including regulating functions of other cistrons.

This term has replaced the definition of a gene. Monocistronic transcription unit will have all the regulatory and coding sequences for a single polypeptide, whereas polycistronic may have coding sequences for more than one polypeptide.

In eukaryotic cells almost all the messenger RNAs are monocistronic. In prokaryotes, *lac* operon coding sequence would be an example of polycistronic DNA region.

Q. 5 Give any six features of the human genome.

Ans. *Salient features of human genome*

(i) The human genome contains 3164.7 million nucleotide bases.

(ii) The average gene consists of 30000 the largest know human gene being dystrophin at 2.4 Million bases.

(iii) The total number of genes is estimated to be 30000 and 99.9% nucleotide bases are exactly the same in all people.

(iv) The functions are unknown for over 50% of the discovered genes.

(v) Less than 2% of the genome codes for proteins.

(vi) The human genome contains large repeated sequences.

(vii) The repeated sequence is thought to have no direct coding functions but they throw light on chromosome structures, dynamics and evolution.

(viii) Chromosome I has most genes (2968) and the Y has the fewest genes (231).

(ix) Scientists have identified about 1.4 million locations where single base DNA sequence differences called **SNPs** or Single Nucleotide Polymorphisms occur in humans.

Q. 6 During DNA replication, why is it that the entire molecule does not open in one go? Explain replication fork. What are the two functions that the monomers (dNTPs) play?

Ans. While replicating, the entire DNA molecule to keep the whole molecule stabilised does not open in one go because it would be highly expens energetically. Actually unwiding creates tension in the molecule as uncoiled parts.

Actually, unwinding creates tension in the molecule as uncoiled parts start forming super coils due to the interaction of exposed nucleotides.

Instead, helicase enzyme acts on the double strand at *ori* site (origin of replication) and a small stretch is unzipped. Immediately, it is held and stabilised by single strand binding proteins.

Slowly with the help of enzymes, exposed strands are copied as a point of unwinding moves and ahead in both directions.

It gives an appearance of Y-shaped structure which is called replication fork.

The two functions that the monomer units of NTPs play are

(i) They pair up with exposed nucleotides of the template strand and make phosphodiester linkages and release a pyrophosphate.

(ii) Hydrolysis of this pyrophosphate by enzyme pyrophosphatase releases energy that will facilitate making hydrogen bonds between free nucleotides and bases of the template strand.

Q. 7 Retroviruses do no follow central dogma. Comment.

Ans. Retroviruses do not follow central dogma of biology (DNA $\rightarrow$ RNA $\rightarrow$ Protein) because their genetic material is not DNA. Instead they have RNA that is converted to DNA by the enzyme reverse transcriptase.

Q. 8 In an experiment, DNA is treated with the compound which tends to place itself amongst the stacks of nitrogenous base pairs. As a result of this, the distance between two consecutive base increases. From 0.34–0.44 nm calculate the length of DNA double helix (which has 2×10^9 bp) in the presence of saturating of this compound.

Ans. The length of DNA double helix = $2 \times 10^9 \times 0.44 \times 10^{-9}$/ bp.

Q. 9 What would happen if histones were to be mutated and made rich in acidic amino acids such as aspartic acid and glutamic acid in place of basic amino acids such as lysine and arginine?

Ans. If histones were mutated and made rich in acidic amino acids. They will not be able to serve the purpose of keeping the DNA coiled around them. This is because DNA is negatively charged molecule and histones are positively charged because of basic amino acids.

So, they are attracted to each other. If histones become negatively charged, instead of binding, they will rather repel DNA. The packaging of DNA in eukaryotes would not happen. Consequently, the chromatin fibre would not be formed.

Q. 10 Recall the experiments done by Frederick Griffith, Avery, MacLeod and McCarty, where DNA was speculated to be the genetic material. If RNA, instead of DNA was the genetic material, would the heat killed strain of *Pneumococcus* have transformed the R-strain into virulent strain? Explain.

Ans. RNA is more liable and prone to degradation (owing to the presence of 2'OH group in its ribose). Hence, heat-killed S-stain may not have retained its ability to transform the R-strain into virulent form if RNA was its genetic material.

Q. 11 You are repeating the Hershey-Chase experiment and are provided with two isotopes ^{32}P and ^{15}N (in place of ^{35}S in the original experiment). How does you expect your results to be different?

Ans. Use of ^{15}N will be inappropriate because method of detection of ^{32}P and ^{15}N different (^{32}P being a radioactive isotope while ^{15}N is non-radioactive but is the heavier isotope of nitrogen).

Even if ^{15}N was radioactive then its presence would have been detected, both inside the cell (^{15}N incorporated as introgenous base in DNA) as well as in the supernatant, because ^{15}N would also get incorporated in amino group of amino acids in proteins. Hence, the use of ^{15}N would not give any conclusive results.

Q. 12 There is only one possible sequence of amino acids when deduced from a given nucleotides. But multiple nucleotides sequence can be deduced from a single amino acid sequence. Explain this phenomena.

Ans. Some amino acids are coded by more then one codon (known as degeneracy of codons), hence, on deducing a nucleotide sequence from an amino acid sequence, multiple nucleotide sequence will be obtained, *e.g.,* Ile (Isoleucine) has three codons AUU, AUC, AUA. Hence, a dipeptide Met-Ile can have the following nucleotide sequence.

(i) AUG-AUU (ii) AUG-AUC (iii) AUG-AUA

And if, we deduce amion acid sequence from the above nucleotide sequences, all the three will code for Met-Ile.

Q. 13 A single base mutation in a gene may not 'always' result in loss or gain of function. Do you think the statement is correct? Defined your answer.

Ans. The statement is correct. Because of degeneracy of codons, mutations at third base of codon, usually does not result into any change is phenotype. This is called silent mutations.

On other hand, if codon is changed in away that now it specifies another amino acid, it may other the protein function as it happens in cse of β-globulin of haemoglobin protein. Where a substitution of valine instead of glutamic acid causes change in its structure and function, and resulting into sickle-cell trait.

Q. 14 A low level of expression of *lac* operon occurs at all the time. Can you explain the logic behind this phenomena.

Ans. In the complete absence of expression of lac operon, permease will not be synthesised which is essential for transport of lactose from medium into the cells. And if lactose cannot be transported into the cell, then it cannot act as inducers. Hence, cannot relieve the *lac* operon from its repressed state.

Q. 15 How has the sequencing of human genome opened new windows for treatment of various genetic disorders. Discuss amongst your classmates.

Thinking Process

In 1990, US department of energy and National Institute of Health Embarked and Coordinated on the project of sequencing human genome called HGP or Human Genome Project.

Ans. The sequencing of human genome helped in enhancing the basic understanding of genetics and immunity to various disorders. Various genes that cause genetic disorders were identified with the help of this project.

It was found that more than 1200 genes are responsible for common human cardiovascular diseases, endocrine diseases (like diabetes), neurological, disorders (like Alzeimer's disease, cancers and many more. These diseases can be treated easily by knowing the particular gene responsible for the particular disease.

Q. 16 The total number of genes in humans is far less (< 25000) than the previous estimate (up to 140000 gene). Comment.

Ans. The total number of genes is estimated at 25000 much lower than previous estimates of 140000 that had been based on extrapolations from gene-rich areas as opposed to a composite of gene-rich and gene-poor areas.

Almost all (99.9%) nucleotide bases are exactly the same in all people. Functions for over 50% discovered genes are not known yet. Scientist have identified about 1.4 million locations where single-base DNA difference (SNPs or Single Nucleotide Polymorphisms) occur in humans.

This information promises to revolutionise the processes of finding chromosomal locations for disease-associated sequence and tracing human history.

Q. 17 Now, sequencing of total genomes is getting less expensive day by day. Soon it may be affordable for a common man to get his genome sequenced. What in your opinion could be the advantage and disadvantage of this development?

Ans. Human genome helps to find out the complete genome sequence of the human. It has many advantages and disadvantages.

Some important advantages

It provides the knowledge of the effects of variations of DNA among individuals can revolutionise the ways to diagnose, treat and prevent many diseases that affect humans. It also provides clues to the understanding of human biology. It helps to find out the human evolution. Identification through DNA forensics is also possible.

Some important disadvantages

People might discover and untreatable genetic disease. People may abuse the knowledge obtained from the HGP. Problem can occur for the ownership of the genetic test result and the patenting of human genes and DNA. People believe that they are special and unique in their own ways and may wish to remain like that.

Q. 18 Would it be appropriate to use DNA probes such as VNTR in DNA fingerprinting of a bacteriophage?

Ans. Bacteriophage does not have repetitive sequences such as VNTRs in its genome, as its genome is very small and have all the coding sequence. DNA finger printing is not done for phages.

Q. 19 During *in vitro* synthesis of DNA, a researcher used 2′, 3′-dideoxy cytidine triphosphate as raw nucleotide in place of 2′-deoxy cytidine. What would be the consequence?

Ans. Further polymerisation would not occur, as the 3′ OH on sugar is not there to add a new nucleotide for forming ester bond.

Q. 20 That background information did Watson and Crick have made available for developing a model of DNA? What was their contribution?

Ans. **Watson** and **Crick** had the following informations which helped them to develop a model of DNA.

(i) **Chargaff's** Law suggesting A = T and C = G

(ii) **Wilkins** and **Rosalind Franklin**'s work on DNA crystal's X-ray diffraction studies about DNAs physical structure.

Watson and **Crick** proposed

(a) Pattern of complementary bases pair

(b) Semi-conservative replication

(c) Mutation through tautomerism

Q. 21 What are the functions of

(i) methylated guanine cap?

(ii) poly-A 'tail' in a mature on RNA?

Ans. **(i)** Methylated guanine cap helps in binding of *m*RNA to smaller ribosomal sub-unit during initiation of translation.

(ii) Poly-A tail provides longevity to *m*RNA's life. Tail length and longevity of *m*RNA are positively correlated.

Q. 22 Do you think that the alternate splicing of exons may enable a structural gene to code for several isoproteins from one and the same gene? If yes, how? If not, why so?

Ans. Functional *m*RNA of structural genes need not always include all of its exons. This alternate splicing of exons is sex-specific, tissue-specific and even developmental stage-specific. By such alternate splicing of exons, a single gene may encode for several isoproteins and/or proteins of similar class.

In absence of such a kind of splicing, there should have been new genes for every protein/isoprotein. Such an extravagancy has been avoided in natural phenomena by way of alternate splicing.

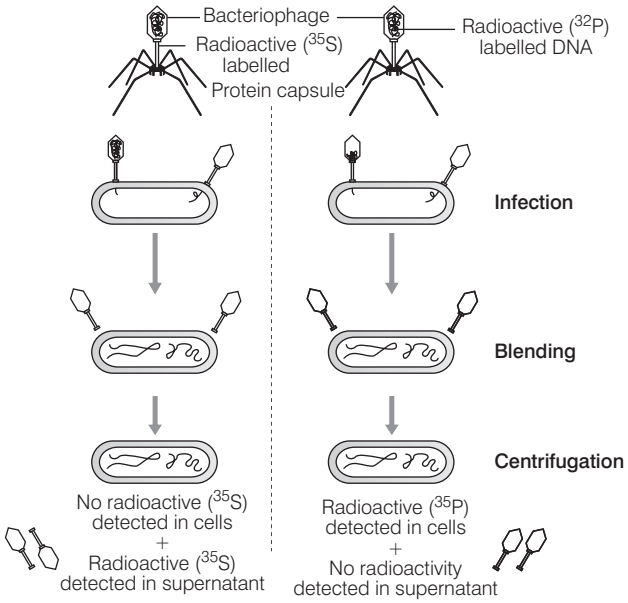
Q. 23 Comment on the utility of variability in number of tandem repeats during DNA fingerprinting.

Ans. Tandemness in repeats provides many copies of the sequence for finger-printing and variability in nitrogen base sequences present in them. Being individual-specific, this proves to be useful in the process of DNA fingerprinting.

Long Answer Type Questions

Q. 1 Give an account of Hershey and Chase experiment. What did it conclusively prove? If both DNA and proteins contained phosphorus and sulphur do you think the result would have been the same?

Ans. **Hershey** and **Chase** conducted experiments on bacteriophage to prove that DNA is the genetic material.



Hershey and Chase experiment

(i) Some bacteriophage virus were grown on a medium that contained radioactive phosphorus (^{32}P) and some in another medium with radioactive sulphur (^{35}S).

(ii) Viruses grown in the presence of radioactive phosphorus (^{32}P) contained radioactive DNA.

(iii) Similar viruses grown in presence of radioactive sulphur (^{35}S) contained radioactive protein.

(iv) Both the radioactive virus types were allowed to infect *E. coli* separately.

(v) Soon after infection, the bacterial cells were gently agitated in blender to remove viral coats from the bacteria.

(vi) The culture was also centrifuged to separate the viral particle from the bacterial cell.

Observations and Conclusions

(i) Only radioactive ^{32}P was found to be associated with the bacterial cell, whereas radioactive ^{35}S was only found in surrounding medium and not in the bacterial cell.

(ii) This indicates that only DNA and not protein coat entered the bacterial cell.

(iii) This proves that DNA is the genetic material which is passed from virus to bacteria and not protein.

If both DNA and proteins contained phosphorus and sulphur, the result might change.

In case (i)

Radioactive ^{35}S and + Bacteriophage ^{32}P labelled protein capsule $\longrightarrow$ No radioactive ^{35}S and ^{32}P Detected in cells + Radioactivity (^{35}S and ^{32}P) detected in supernatant

In case (ii)

Radioactive ^{35}S and ^{32}P lebelled DNA + Bacteriophage $\longrightarrow$ Radioactive ^{32}P and ^{35}S Detected in cells + No radioactivity detected in supernatant

Q. 2 During the course of evolution why DNA was choosen over RNA as genetic material. Give reasons by first discussing the desired criteria in a molecule that can act as genetic material and in the light of biochemical differences between DNA and RNA.

Ans. *A molecule that can act as a genetic material must fulfil the following*

(i) It should be able to generate its replica (replication).

(ii) It should chemically and structurally be stable.

(iii) It should provide the scope for slow changes (mutation) that are required for evolution.

(iv) It should be able to express itself in the form of Mendelian.

Biochemical differences between DNA and RNA

(i) Both nucleic acid (DNA and RNA) are able to direct their duplication proteins fails for the first criteria.

(ii) RNA is reactive, it also acts are catalyst, hence DNA is less reactive and structurally more stable than RNA.

(iii) Presence of thymine at the place of uracil also confers additional stability to DNA.

Q. 3 Give an account of post transcriptional modifications of a eukaryotic *m*RNA.

Thinking Process

Post-transcriptional modifications include the modification of the mRNA transcript synthesised by RNA polymerase II (in eukaryotes).

Ans. **Post-transcriptional Modifications**

The primary transcripts are non-functional, containing both the coding region, exon and non-coding region, intron in RNA and are called heterogenous RNA or *hn*RNA.

In eukaryotes, three types of RNA polymerases are found in the nucleus

(i) **RNA polymerase I** transcribes *r*RNAs (28 S and 5.8 S).

(ii) **RNA polymerase II** transcribes the precursor of *m*RNA (called heterogeneous nuclear RNA or *hn*RNA).

(iii) **RNA polymerase III** transcribes *t*RNA, 5 S *r*RNA and *sn*RNAs (small nuclear RNAs).

The *hn*RNA undergoes two additional processes called **capping** and **tailing**.

In capping, an unusual nucleotide, methyl guanosine triphosphate is added to the 5′-end of *hn*RNA.

In tailing, adenylate residues (about 200-300) are added at 3′-end in a template independent manner.

Now the *hn*RNA undergoes a process where the introns are removed and exons are joined to form *m*RNA by the process called **splicing**.

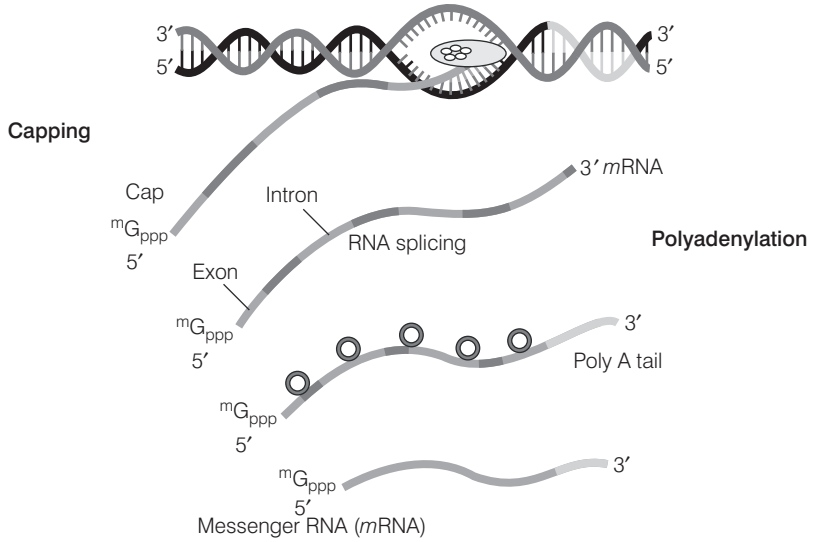


Diagram representation of a post transcriptional modification in eukaryotes

Note *In prokaryotes, mRNA does not require any processing.*

Q. 4 Discuss the process of translation in detail.

Thinking Process

Translation is the process of synthesis of protein from mRNA with the help of ribosome. A translational unit in mRNA from 5′→3′ comprises of a start codon, region coding for a polypeptide, a stop codon and Untranslated Regions (UTRs) at both 5′-end and 3′-end for efficient process.

Ans. *There are three-stages of protein synthesis*

(i) **Initiation**

Assembly of Ribosomes on m*RNA* In prokaryotes, initiation requires the large and small ribosome subunits, the *m*RNA, initiation *t*RNA and three Initiation Factors (IFs).

Activation of Amino Acid Amino acids become activated by binding with aminoacyl *t*RNA synthetase enzyme in the presence of ATP.

$$\text{Amino acid (AA)} + \text{ATP} \xrightarrow[\text{synthetases}]{\text{Aminoacy}\,t\,\text{RNA}} \text{AA-AMP-Enzyme complex} + P_i$$

Transfer of Amino Acid to t*RNA* The AA-AMP-enzyme complex formed reacts with specific *t*RNA to form aminoacyl *t*RNA complex.

$$\text{AA-AMP-Enzyme complex} + t\text{RNA} \longrightarrow \text{AA}\,t\text{RNA} + \text{AMP} + \text{Enzyme}.$$

The cap region of *m*RNA binds to the smaller subunit of ribosome.

The ribosome has two sites, A-site and P-site.

The smaller subunit first binds the initiator *t*RNA then and then binds to the larger subunit so, that initiation codon (AUG) lies on the P-site.

The initiation *t*RNA, *i.e.,* methionyl *t*RNA then binds to the P-site.

(ii) **Elongation**

Another charged aminoacyl *t*RNA complex binds to the A-site of the ribosome.

Peptide bond formation and movement along the *m*RNA called translocation. A peptide bond is formed between carboxyl group (—COOH) of amino acid at P-site and amino group (—NH) of amino acid at A-site by the enzyme peptidyl transferase.

The ribosome slides over *m*RNA from codon to codon in the 5′→3′ direction.

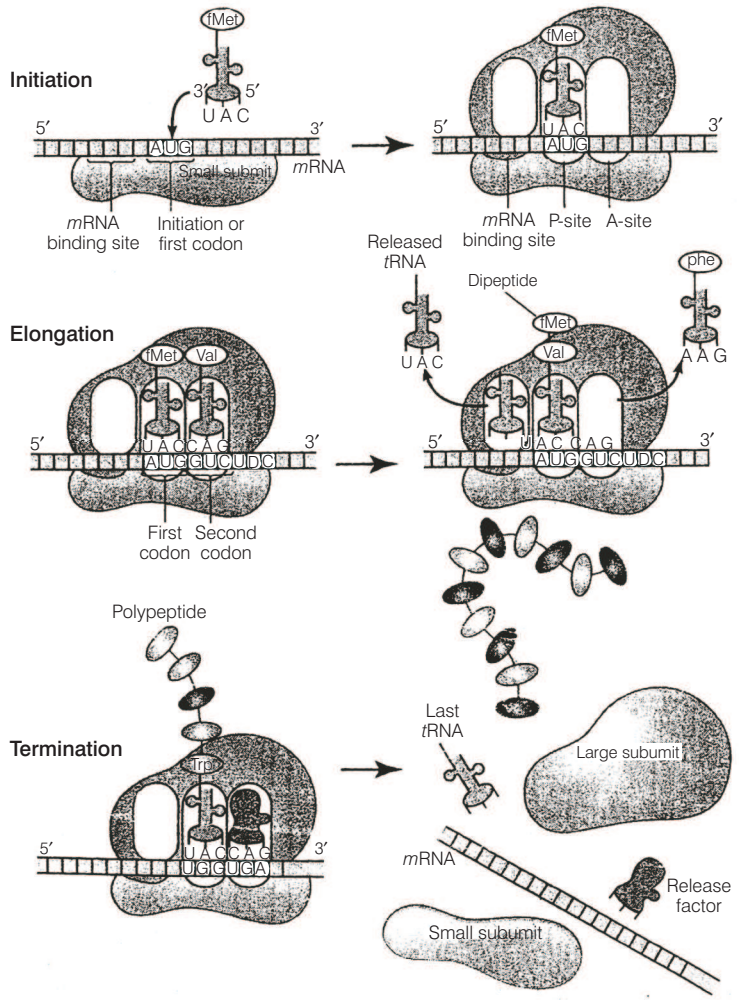
According to the sequence of codon, amino acids are attached to one another by peptide bonds and a polypeptide chain is formed.

(iii) **Termination**

When the A-site of ribosome reaches a termination codon which does not code for any amino acid, no charged *t*RNA binds to the A-site.

Dissociation of polypeptide from ribosome takes place which is catalysed by a '**release factor**'.

There are three **termination codons,** *i.e.*, UGA, UAG and UAA.



Process of translation

Q. 5 Define an operon, giving an example, explain an inducible operon.

Ans. The concept of operon was first proposed in 1961, by **Jacob** and **Monad**. An operon is a unit of prokaryotic gene expression which includes coordinately regulated (structural) genes and control elements which are recognised by regulatory gene product.

Components of an Operon

(i) **Structural gene** The fragment of DNA which transcribe *m*RNA for polypeptide synthesis.

(ii) **Promoter** The sequence of DNA where RNA polymerase binds and initiates transcription of structural genes is called promoter.

(iii) **Operator** The sequence of DNA adjacent to promoter where specific repressor protein binds is called operator.

(iv) **Regulator gene** The gene that codes for the repressor protein that binds to the operator and suppresses its activity as a result of which transcription will be switched off.

(v) **Inducer** The substrate that prevents the repressor from binding to the operator, is called an inducer. As a result transcription is switched on. It is a chemical of diverse nature like metabolite, hormone substrate, etc.

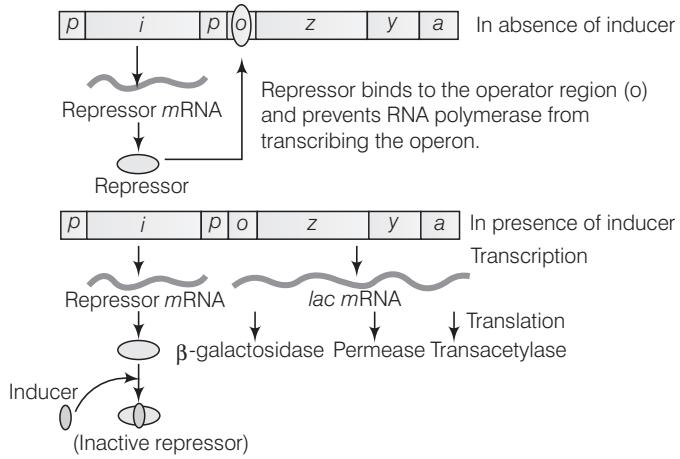
Inducible Operon System

An inducible operon system is a regulated unit of genetic material which is switched on in response to the presence of a chemical. *e.g.,* the lactose or *lac*-operon of *E.coli*.

The lactose operon The *lac z*, *y*, *a* genes are transcribed from a *lac* transcription unit under the control of a single promoter. They encode enzyme required for the use of lactose as a carbon source. The *lac i* gene product, the lac repressor, is expressed from a separate transcription unit upstream from the operator.

lac operon consists of **three structural genes** (z, y and a), operator, promoter and a separate regulatory gene.

The three structural genes (*a*, *y* and *a*) transcribe a polycistronic *m*RNA.



***Lac* operon**

Gene *z* codes for β-galactosidase (β-gal) enzyme which breaks lactose into galactose and glucose.

Gene *y* codes for permease, which increases the permeability of the cell to lactose.

Gene *a* codes for enzyme transacetylase, which catalyses the transacetylation of lactose in its active form.

When Lactose is Absent

(i) When lactose is absent, *i* gene regulates and produces repressor *m*RNA which translate repression.

(ii) The repressor protein binds to the operator region of the operon and as a result prevents RNA polymerase to bind to the operon.

(iii) The operon is **switched off.**

When Lactose is Present

(i) Lactose acts as an inducer which binds to the repressor and forms an inactive repressor.

(ii) The repressor fails to bind to the operator region.

(iii) The RNA polymerase binds to the operator and transcript *lac m*RNA.

(iv) *lac m*RNA is polycistronic, *i.e.,* produces all three enzymes, β-galactosidase, permease and transacetylase.

(v) The *lac* operon is **switched on.**

Q. 6 'There is a paternity dispute for a child'. Which technique can solve the problem? Discuss the principle involved.

Ans. DNA fingerprinting is the technique used in solving the paternity dispute for a child. DNA fingerprinting is a technique of determining nucleotide sequences of certain areas of DNA which are unique to each individual.

The basis of DNA fingerprinting is DNA polymorphism. Although the DNA from different individuals is more alike than different, there are many regions of the human chromosomes that exhibit a great deal of diversity. Such variable sequences are termed 'polymorphic' (meaning many forms).

A special type of polymorphism, called VNTR (Variable Number of Tandem Repeats), is composed of repeated copies of a DNA sequence that lie adjacent to one another on the chromosome. Since, polymorphism is the basis of genetic mapping of human.

Q. 7 Give an account of the methods used in sequencing the human genome.

Ans. Sequencing of human genome has made it possible to understand the link between various genes and their functions. If there are any gene defects that express as disorders or that increase the susceptibility of an individual to a disease then specific gene therapies can be worked out

Methodologies of human genome sequencing

The methods involve two major approaches

(i) **Expressed Sequence Tags** (ESTs) This method focusses on identifying all the genes that are expressed as RNA.

(ii) **Sequence annotation** It is an approach of simply sequencing the whole set of genome that contains all the coding and non-coding sequences, and later assigning different regions in the sequence with functions.

For sequencing, first the total DNA from cell is *i.e.*, solated and broken down in relatively small sizes as fragments.

There DNA fragments are cloned in suitable host using suitable vectors. When bacteria is used as vector, they are called Bacterial Artificial Chromosomes (BAC) and when yeast is used as vector, they are called Yeast Artificial Chromosomes (YACs).

Frederick Sanger developed a principle according to which the fragments of DNA are sequenced by automated DNA sequences.

On the basis of overlapping regions on DNA fragments, these sequences are arranged accordingly. For alignment of these sequences, specialised computer-based programmes were developed.

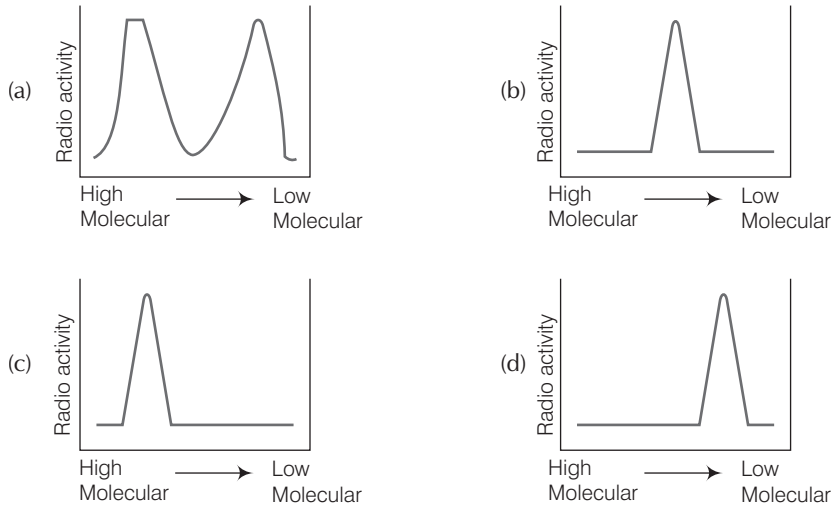
Finally, the genetic and physical maps of the genome were constructed by collecting information about certain repetitive DNA sequences and DNA polymorphism, based on endonuclease recognition sites.

Q. 8 List the various markers that are used in DNA fingerprinting.

Ans. **Dr. Alec Jeffreys** developed the technique of DNA fingerprinting in an attempt to identify DNA marker for inherited diseases.

DNA fingerprinting uses short nucleotide repeats called Variable Number Tandem Repeats (VNTRs) as markers. VNTRs vary from person to person and are inherited from one generation to the next. Only closely individuals have similar VNTRs.

Q. 9 Replication was allowed to take place in the presence of radioactive deoxynucleotides precursors in *E.coli* that was a mutant for DNA ligase. Newly synthesised radioactive DNA was purified and strands were separated by denaturation. These were centrifuged using density gradient centrifugation. Which of the following would be a correct result?



Ans. In above case, as *E.coli* is a mutant for DNA ligase, it will result in no further joining of Okazaki fragments on lagging strand.

This will ultimately result into the formation of both high molecular weight fragments (on leading strands) and low molecular weight fragments (on lagging strand). Hence, only the graph (a) could be the appropriate result after centrifugation.

4

Reproductive Health

Multiple Choice Questions (MCQs)

Q. 1 The method of directly injecting a sperm into ovum in assisted by reproductive technology is called

(a) GIFT (b) ZIFT (c) ICSI (d) ET

Ans. *(c)* **ICSI** (Intra Cytoplasmic Sperm Injection) is a specialised procedure to form an embryo in the laboratory in which a sperm is directly injected into the ovum placed in a nutrient broth.

GIFT (Gamete Intra Fallopian Transfer) is a method to transfer an ovum collected from a donor into the Fallopian tube of another female who cannot produce one, but can provide suitable environment for fertilisation and further development.

ZIFT (Zygote Intra Fallopian Transfer) is a method (similar to *in vitro* fertilisation and embryo transfer in which the zygote (early embryo) up to 8 blastomeres is transferred directly into the Fallopian tube.

ET (Embryo Transfer) is a method in which the fertilisation is done *in vitro* and the formed zygote is transferred into the uterus of the female who cannot conceive.

Q. 2 Increased IMR and decreased MMR in a population will

(a) cause rapid increase in growth rate
(b) result in decline in growth rate
(c) not cause significant change in growth rate
(d) result in an explosive population/exp

Ans. *(c)* **IMR** (Infant Mortility Rate) and **MMR** (Maternal Mortility Rate) both are responsible for affecting the growth rate inversely. It means decline in IMR as well as MMR will result in high population growth and *vice-versa*.

Here, if IMR has been increased then it will result in decline in growth rate. While, decreased MMR will cause rapid increase in growth rate.

Therefore, in the above situation, if IMR has been increased and MMR has been decreased in a population, it will not cause any significant change in growth rate.

Q. 3 Intensely lactating mothers do not generally conceive due to the

(a) suppression of gonadotropins
(b) hypersecretion of gonadotropins
(c) suppression of gametic transport
(d) suppression of fertilisation

Thinking Process

The natural methods of birth control work on the principle of avoiding the meeting of ovum and sperm. One of these methods is lactational amenorrhea, that is based on the principle that during the period of lactation after parturition, ovulation does not occur.

Ans. ***(a)*** Breast feeding is one of the natural contraceptive methods. It reduces fecundity by affecting the production of certain reproductive hormones. It is known to suppress the production of **Gonadotropin-Releasing Hormone** (GRH) and **Follicle Stimulating Hormone** (FSH).

The release of these hormones triggern ovulation. Breast feeding also leads to increased level of prolactin, a hormone that inhibits ovulation. So, even when a woman ovulates, her likelihood of conceiving is low if she is breast-feeding.

Q. 4 Sterilisation techniques are generally full proof methods of contraception with least side effects. Yet, this is the last option for the couples because

I. it is almost irreversible.
II. of the misconception that it will reduce sexual urge/drive.
III. it is a surgical procedure.
IV. of lack of sufficient facilities in many parts of the country.

Choose the correct option

(a) I and III (b) II and III
(c) II and IV (d) I, II, III and IV

Ans. ***(a)*** Surgical methods/sterilisation techniques are generally opted by the male/female partner as a terminal method to prevent any more pregnancies. This method blocks gamete transport and thereby prevent conception.

In males, this is called vasectomy, while in females, this is called tubectomy. It is a surgical and permanent contraceptive method.

Q. 5 A national level approach to build up a reproductively healthy society was taken up in our country in

(a) 1950s (b) 1960s (c) 1980s (d) 1990s

Ans. ***(a)*** India was amongst the first countries in the world to initiate action plans and programmes at a national level to attain total reproductive health as a social goal. These programmes called 'family planning' were initiated in 1951 and were periodically assessed over the past decades.

Creating awareness among people about various reproduction related aspects and providing facilities and support for building up a reproductively healthy society are the major tasks under these programmes.

Q. 6 Emergency contraceptives are effective if used within 72 hrs of

(a) coitus (b) ovulation (c) menstruation (d) implantation

Thinking Process

Progestogens alone or in combination with estrogen can also be used as contraceptive method by females in the form of tablets (pills).

Ans. ***(a)*** Administration of higher doses progestogens or progestogen-estrogen combinations within 72 hrs of coitus have been found to be very effective as emergency contraceptives as they could be used to avoid possible pregnancy due to rape or casual unprotected intercourse. These drugs delay/disrupt the ovulation and fertilisation.

Q. 7 Choose the right one among the statements given below.

(a) IUDs are generally inserted by the user herself.
(b) IUDs increase phagocytosis reaction in the uterus.
(c) IUDs suppress gametogenesis.
(d) IUDs once inserted need not be replaced.

Ans. ***(b)*** Non-mediated IUDs increase phagocytosis of sperms within the uterus and the Cu ions released suppress sperm motility and the fertilising capacity of sperms. Hormone releasing IUDs make the uterus unsuitable for implantation and the cervix hostile to sperms, *e.g.,* progestasert, LNG-20.

Intra Uterine Devices (IUDs) are used as one of the effective and popular contraceptive method. These devices are inserted by doctors or expert nurses in the uterus through vagina. IUDs are presently available as the non-mediated IUDs (*e.g.,* Lipens loop), copper releasing IUDs (Cu-T, Cu-7, Multiload 375) and the hormone releasing IUDs (Progestasert, LNG-20).

IUDs do not suppress gametogenesis as gametogenesis (oogenesis) takes place in the ovary, while IUDs are inserted in the uterus (through vagina) with the help of an doctor or an expert personnel.

Q. 8 Following statements are given regarding MTP. Choose the correct options given below.

I. MTPs are generally advised during first trimester.
II. MTPs are used as a contraceptive method.
III. MTPs are always surgical.
IV. MTPs require the assistance of qualified medical personnel.

(a) II and III (b) II and III (c) I and IV (d) I and II

Thinking Process

MTP (Medical Termination of Pregnancy) is intentional or voluntary termination of pregnancy before full term. It is also known as induced abortion.

Ans. ***(c)*** MTP is considered relatively safe during the first trimester, *i.e.,* up to 12 weeks of pregnancy. Second trimester abortions are much more riskier.

MTP is done to get rid of unwanted pregnancies either due to casual unprotected intercourse or failure of the contraceptive used during coitus or rapes. MTPs are also essential in certain cases where continuation of the pregnancy could be harmful or even fatal either to the mother or to the foetus or both.

MTPs are not always surgical. Certain pills also act as abortants. They function by inducing menstruation which checks the implantation of the zygote or detaches the implanted foetus.

In India, majority of the MTPs are performed illegally by unqualified quacks. These are unsafe and may result in the death of mother. So, MTPs should be done only in the presence of qualified medical personnel.

Q. 9 From the sexually transmitted diseases mentioned below, identify the one which does not specifically affect the sex organs

(a) Syphilis (b) AIDS
(c) Gonorrhoea (d) Genital warts

Ans. ***(b)*** Syphilis, gonorrhoea and genital warts as STD caused by *Treponema pallidum*, *Neisseria gonorrhoeae* and human papilloma virus. These pathogens directly infect and damage sex organs causing ichting fluid discharge, slight pain and swelling of genitalia.

AIDS (Acquired Immuno Deficiency Syndrome) is a set of symptoms caused by HIV virus in humans. It is transmitted through sexual contacts from infected to healthy person. The HIV virus does not directly affect sex organs as such but produce other set of symptoms in the body of infected person.

Q. 10 Condoms are one of the most popular contraceptives because of the following reasons

(a) these are effective barriers for insemination
(b) they do not interfere with coital act
(c) these help in reducing the risk of STDs
(d) All of the above

Ans. ***(d)*** Condoms are barriers made of thin rubber/latex sheath used to cover the penis in the male or vagina and cervix in females. It prevents the deposition of ejaculated semen into the vagina of the female.

Condom should be discarded after a single use. It is also a safe guard against transmission of AIDS and other Sexually Transmitted Diseases (STDs).

Condom should be used regularly and put on before starting coital activity, otherwise sperm containing lubricating fluid may be left in the vagina. They do not interfere with coital act.

Q. 11 Choose the correct statement regarding the ZIFT procedure.

(a) Ova collected from a female donor are transferred to the Fallopian tube to facilitate zygote formation.
(b) Zygote is collected from a female donor and transferred to the Fallopian tube
(c) Zygote is collected from a female donor and transferred to the uterus
(d) Ova collected from a female donor and transferred to the uterus

Ans. ***(b)*** The zygote or early embryo with upto 8 blastomeres is collected from a female donor and transferred into the Fallopian tube, this process is called Zygote Intra Fallopian Transfer or ZIFT.

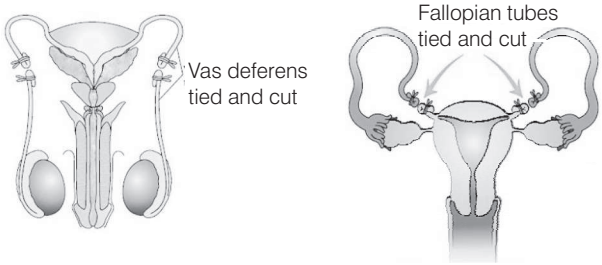
Embryo more than 8 blastomeres is transferred into the uterus by the process called Intra Uterine Transfer or IUT.

When ovum is collected from donar and transferred to Fallopian tube of other female who can not produce ovum- this is known as Gamete Intra Fallopian Transfer (GIFT)

Q. 12 The correct surgical procedure as a contraceptive method is

(a) ovariectomy (b) hysterectomy
(c) vasectomy (d) castration

Ans. *(c)* Surgical methods, also called sterilisation are terminal and permanent methods which block the transport of gametes, thereby preventing conception. In males, this is called vasectomy, while in females, this is called tubectomy.



Vasectomy Tubectomy

Q. 13 Diaphragms are contraceptive devices used by the females. Choose the correct option from the statements given below

I. They are introduced into the uterus.
II. They are placed to cover the cervical region.
III. They act as physical barriers for sperm entry.
IV. They act as spermicidal agents.

(a) I and II (b) I and III
(c) II and III (d) III and IV

Ans. *(c)* Diaphragms, cervical caps and vaults are the barriers made of rubber that are inserted into the female reproductive tract to cover the cervix during coitus. They prevent the entry of sperms through cervix.

Spermicidal agents like creams, jellies and foams are used along with these barriers to increase their contraceptive efficiency.

Very Short Answer Type Questions

Q. 1 Reproductive health refers only to healthy reproductive functions. Comment.

Ans. According to the World Health Organisation (WHO), reproductive health means a total well-being in all aspects of reproduction, *i.e.,* physical emotional, behavioural and social.

Therefore, a society with people having physically and functionally normal reproductive organs and normal emotional and behavioural interactions among them in all sex-related aspects might be called reproductively healthy.

Q. 2 Comment on the reproductive and child healthcare programme of the government to improve the reproductive health of the people.

Ans. India was amongst the first countries in the world to initiate action plans and programmes at a national level to attain total reproductive health as a social goal.

These programmes called 'family planning' were initiated in 1951 and were periodically assessed over the past decades. Improved programmes covering wider reproduction-related areas are currently in operation under the popular name 'Reproductive and Child Healthcare (RCH) programmes'.

Creating awareness among people about various reproduction related aspects and providing facilities and support for building up a reproductively healthy society are the major tasks under these programmes.

Q. 3 The present population growth rate in India is alarming. Suggest ways to check it.

Ans. The present population growth rate in India is alarming. Such an alarming growth rate could lead to an absolute scarcity of even the basic requirements, *i.e.,* food, shelter and clothing, in spite of significant progress made in those areas.

Following are some important ways to overcome this problem

(i) By raising marriageable age of the female to 18 years and that of males to 21 years.

(ii) By promoting use of birth control measures to motivate smaller families.

(iii) By providing incentives to couples with small families.

(iv) By educating people about consequences of uncontrolled population growth.

Q. 4 STDs can be considered as self-invited diseases. Comment.

Ans. Diseases or infections which are transmitted through sexual intercourse are collectively called Sexually Transmitted Diseases (STD) or Venereal Diseases (VD) or Reproductive Tract Infections (RTI).

Though all persons are vulnerable to these infections, their incidences are reported to be very high among persons in the age group of 15-24 years. STDs can be considered as self-invited diseases because one could be free of these *infections by following the simple principles given below*

(i) Avoid sex with unknown partners/multiple partners.

(ii) Always use condoms during coitus.

(iii) In case of doubt, one should go to a qualified doctor for early detection and get complete treatment if diagnosed with disease.

Q. 5 Suggest the reproduction-related aspects in which counselling should be provided at the school level.

Ans. *In following aspects counselling should be provided at the school level*

(i) Introduction of sex education in school that helps in eradicating myths and misconceptions regarding sex-related aspects.

(ii) Proper information about reproductive organs, safe and hygienic sexual practices and Sexually Transmitted Diseases (STDs).

(iii) Awareness of problems due to uncontrolled population growth, social evils like sex-abuse and sex-related crimes, etc.

(iv) Educating people about available birth control options, care of pregnant mothers, post-natal care of mother and child, importance of breast-feeding, equal opportunities for the male and female child.

Q. 6 Mention the primary aim of the 'Assisted Reproductive Technology' (ART) programme.

Ans. 'Assisted Reproductive Technology' (ART) is the collection of certain special techniques. The primary aim of the ART programme is to assist infertile couples to have children through certain special techniques (like ZIFT, IUT, GIFT, ICSI, AI, etc.) where corrective treatment is not possible.

Q. 7 What is the significance of progesterone-estrogen combination as a contraceptive measure?

Ans. Progestogens or progestogen-estrogen combinations play an important role in contraception. They are used in the form of tablets or pills. They inhibit ovulation and hence implantation.

They are also used by females as injections or implants under the skin. Their mode of action is similar to that of pills but their effective periods are longer.

Q. 8 Strict conditions are to be followed in Medical Termination of Pregnancy (MTP) procedures. Mention two reasons.

Ans. *Strict conditions are to be followed in Medical Termination of Pregnancy (MTP) procedures due to following two reasons*

(a) to get rid of unwanted pregnancies.

(b) it is also essential when the foetus is suffering from an incurable disease or when continuation of the pregnancy could be harmful or even fatal to the mother and or foetus.

Q. 9 Males in whom testes fail to descend to the scrotum are generally infertile. Why?

Ans. Since, the testes are very sensitive to temperature, if they do not descend into the scrotum prior to adolescence, then they will stop producing sperms that will lead to infertility in males.

Q. 10 Mention two advantages of lactational amenorrhea as a contraceptive method.

Ans. *The two advantages of lactational amenorrhea as a contraceptive method are mentioned as below*

(i) If the mother is breast feeding completely, she would not ovulate, so chances of conception would be low.

(ii) She would not need to use any pill or devices for birth control. So, there will be no side effects.

Short Answer Type Questions

Q. 1 Suggest some important steps that you would recommend to be taken to improve the reproductive health standards in India.

Thinking Process

Reproductive health means total well being in all aspects of reproduction, i.e., physical, emotional, behavioural, social and physical.

Ans. *Following measures are needed to be taken to improve the reproductive health standards in India*

(i) Providing infrastructural facilities and professional expertise to attain reproductive health.

(ii) Educating people about birth control methods, care of pregnant mothers, importance of breast feeding, safe and hygienic sexual practices and safeguard against STDs.

(iii) Introduction of sex education in schools to give proper information to the young minds about sex-related aspects.

(iv) Help of audio-visual and print media to create awareness among people about reproduction related aspects.

(v) Awareness of problems due to population explosion, social evils like sex-abuse and sex-related crimes.

(vi) Statutory ban on amniocentesis to legally check female foeticides.

Q. 2 The procedure of GIFT involves the transfer of female gamete to the Fallopian tube. Can gametes be transferred to the uterus to achieve the same result? Explain.

Ans. The procedure of GIFT involves the transfer of female gamete to the Fallopian tube. Gametes cannot be transferred to the uterus to achieve the same result because the uterine environment is not congenial for the survival of the gamete.

If directly transferred to the uterus they will undergo degeneration or could be phagocytosed and hence, viable zygote would not be formed.

Q. 3 Copper ions-releasing IUDs are more efficient than non-medicated methods. Why?

Ans. Intra Uterine Devices (IUDs) are inserted in the uterus through vagina and are presently available as the non-medicated IUDs,copper releasing IUDs and hormone releasing IUDs *Cu ions-releasing IUDs are more efficient methods because*

(i) Cu ions released suppress sperm motility and fertilising capacity of sperms.

(ii) It increases phagocytosis of sperms within the uterus.

(iii) It is one of the safest, most effective, convenient and least expensive reversible contraceptives available.

(iv) It has no systemic effects and can be safely used by breast-feeding women.

Q. 4 What are the probable factors that contributed to population explosion in India?

Ans. *Following are some factors that have probably contributed to population explosion in India*

(i) Ignorance and complete lack of awareness about the ill effects of increasing population especially in rural regions.
(ii) Poverty and illiteracy
(iii) Social stigmas about girl child and desire to have boy child.
(iv) Decline in death rate.
(v) Decline in maternal and infant mortality rate.
(vi) Increase in the young, reproductive age population.

Q. 5 Briefly explain IVF and ET, What are the conditions in which these methods are advised?

Ans. IVF refers to *in vitro* fertilisation and ET refers to embryo transfer. Gametes from the male and female are collected hygienically and induced to fuse in the laboratory set up under simulated conditions.

The zygote formed is collected and is introduced into the uterus of a host or surrogate mother at an appropriate time (secretory phase). Early embryos (up to 8 cell) are generally transferred to the Fallopian tube whereas embryos with more than 8 cells are transferred to the uterus.

Q. 6 What are the advantages of natural methods of contraception over artificial methods?

Thinking Process

Natural methods of contraception work on the principle of avoiding chances of ovum and sperm meeting.

Ans. As no medicines or devices are used in these methods, side effects are almost nil.

Note *Chances of failure of these methods are also high.*

Q. 7 What are the conditions in which medical termination of pregnancy is advised?

Ans. Medical termination of pregnancy is carried out to get rid of unwanted pregnancies. It is also essential when the foetus is suffering from an incurable disease or when continuation of the pregnancy could be harmful or even fatal to the mother and/or foetus.

Q. 8 Comment on the essential features required for an ideal contraceptive.

Ans. *An ideal contraceptive should*

(i) be easily available
(ii) effective and reversible with least or no side effects
(iii) no interference with the sexual drive/desire or the sexual act of the user
(iv) be user-friendly

Q. 9 All reproductive tract infections RTIs are STDs, but all STDs are not RTIs. Justify with example.

Ans. Among the common STDs, hepatitis-B and AIDS are not infections of the reproductive organs though their mode of transmission could be through sexual conact also.

All other diseases like gonorrhoea, syphilis, genital herpes, hepatitis-B are transmitted through sexual contact and are also infections of the reproductive tract so, there are STDs and RTI, Whereas, AIDS and hepatitis are STDs but not RTI.

Long Answer Type Questions

Q. 1 What are the assisted reproductive techniques practised to help infertile couples? Describe any three techniques.

Thinking Process

The infertile couples could be assisted to have children through certain special techniques called Assisted Reproductive Technologies (ART).

Ans. *ART techniques are described as follows*

(i) **Test-tube Baby Programmes** In this method, ova from the wife/donor (female) and the sperms from the husband/donor (male) are collected and are induced to form zygote under simulated conditions in the laboratory. This process is called *In Vitro* Fertilisation (IVF).

The zygote or early embryo with upto 8 blastomeres is transferred into the Fallopian tube (process is called Zygote Intra Fallopian Transfer or ZIFT) and embryo with more than 8 blastomeres is transferred into the uterus (process is called Intra Uterine Transfer or IUT).

In females who cannot conceive, embryos formed by fusion of gametes within the female (called *in vivo* fertilisation) are transferred.

(ii) **Gamete Intra Fallopian Transfer** (GIFT) It is the transfer of an ovum collected from a donor into the Fallopian tube of another female who cannot produce one, but can provide suitable environment for fertilisation and further development of the embryo.

(iii) **Artificial Insemination** (AI) In this method, the semen collected either from the husband or a healthy donor is artificially introduced into the vagina or into the uterus (Intra Uterine Insemination or IUI).

This technique is used in cases where the male is unable to inseminate sperms in the female reproductive tract or due to very low sperm counts in the ejaculation.

Q. 2 Discuss the mode of action and advantages/disadvantages of hormonal contraceptives.

Thinking Process

Intra Uterine Devices (IUDs) are effective and popular method of contraception.

Ans. *Intra Uterine Devices are presently available as*

(a) Non-medicated IUDs (*e.g.,* Lippes loop).

(b) Copper releasing IUDs (*e.g.,* Cu-T, Cu-7, Multiload 375).

(c) Hormone releasing IUDs (*e.g.,* Progestasert, LNG-20).

Mode of Action of Hormonal Contraceptives

The hormones releasing IUDs, make the uterus unsuitable for implantation and the cervix hostile to the sperms. Progesterone can also be used as injections and implants (slow release of hormones) to inhibit ovulation.

Advantages of Hormonal Contraceptives

Administration of progestogens or progestogen-oestrogen combinations or IUDs within 72 hrs of intercourse have been found to be effective as emergency contraceptives as they could be used to avoid possible pregnancy due to rape or causal unprotected intercourse.

Disadvantages of Hormonal Contraceptives

(i) IUDs are suggested as ideal contraceptives for the females but they can have serious side effects.

(ii) Can cause allergic reaction.

(iii) If displaced, can cause tissue damage and profuse bleeding.

(iv) IUDs can damage the normal hormonal balance and later even if desired, pregnancy may not be achieved.

(v) Artificial intake can disrupt normal hormonal interactions in the body system.

Q. 3 STDs are a threat to reproductive health. Describe any two such diseases and suggest preventive measures.

Ans. Diseases or infections which are transmitted through sexual intercourse are collectively called Sexually Transmitted Diseases (STDs) or Venereal Diseases (VD) or Reproductive Tract Infections (RTI).

Though all persons are vulnerable to these infections, their incidences are reported to be very high among persons in the age group of 15-24 years. STDs can be considered as self-invited diseases.

STDs include gonorrhoea, syphilis, genital herpes, chlamydiasis, genital warts, trichomoniasis, hepatitis-B, HIV. These diseases may cause some complications Pelvic Inflammatory Diseases (PID), abortions, still births, ectopic pregnancies, infertility, or even cancer of the reproductive tract.

Hepatitis-B and HIV are such diseases that get transmitted by the following ways besides sexual contacts

(i) Sharing of injection needles or surgical instruments with infected persons.

(ii) Transfusion of infected blood.

(iii) Transfer from infected mother to the foetus through placenta.

Preventive Measures

By following simple principles, STDs can be prevented

(i) Avoid sex with unknown partners/multiple partners.

(ii) Always use condoms during coitus.

(iii) Contact a qualified doctor for any doubt in early stage of infection.

Q. 4 Do you justify the statutory ban on amniocentesis in our country? Give reasons.

Ans. *Yes*, the ban is necessary because amniocentesis is misused now-a-days. It is used to determine the sex of the foetus and in many cases it led to female foeticide. It became so serious that it disturbed the male female ratio that can have a negative impact on society.

The test is actually meant to determine the genetic defects or metabolic disorders in foetus by doing a chromosomal analysis. In such extreme cases that would be incurable, a decision to abort the foetus could be taken.

Q. 5 Enumerate and describe any five reasons for introducing sex education to school-going children.

Ans. *The reasons for introducing sex education to school-going children are as follows*

(i) At school level, children from age group 12 and above should be counselled for reproductive system, processes and practices and importance of safe and responsible sex.

(ii) Sex related issues and problems like adolescence changes, menstrual cycle, menstrual problems, unwanted pregnancy, unsafe abortion, reproductive tract infections (STDs) and cancers.

(iii) They should know about body changes during their age and taught about healthy habits including personal cleanliness and hygiene.

(iv) Students should become part of such education, so that they overcome hesitation and gain confidence to discuss any query with their teacher or parents.

(v) Counselling and awareness regarding reproductive organs, safe and hygienic sexual practices will play an important role to make people reproductively healthy.

3

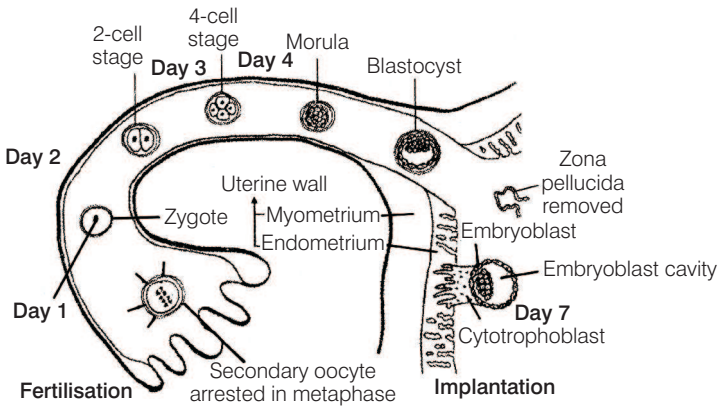
Human Reproduction

Multiple Choice Questions (MCQs)

Q. 1 Choose the incorrect statement from the following

(a) in birds and mammals internal fertilisation takes place
(b) colostrum contains antibodies and nutrients
(c) polyspermy is prevented by the chemical changes in the egg surface
(d) in the human female implantation occurs almost seven days after fertilisation

Ans. *(c)* Polyspermy describes on egg that has been fertilised by more than one sperm. During fertilisation, binding of the sperm to the egg induces depolarisation of the egg plasma membrane that block the entry of additional sperms. Rest all statements are correct.



Q. 2 Identify the wrong statement from the following.

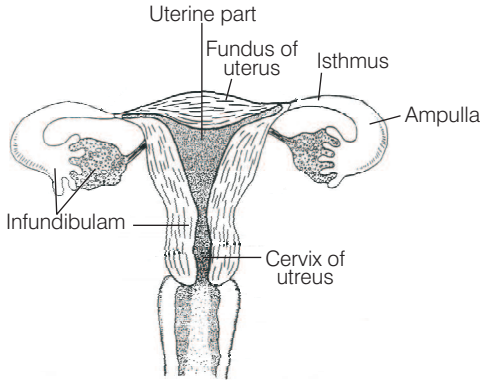
(a) High levels of estrogen triggers the ovulatory surge.
(b) Oogonial cells start to proliferate and give rise to functional ova in regular cycles from puberty onwards.
(c) Sperms released from seminiferous tubules are poorly motile/ non-motile.
(d) Progesterone level is high during the post ovulatory phase of menstrual cycle.

Ans. *(b)* The process of formation of a mature female gamete is called oogenesis. Unlike sperm formation that starts at puberty, egg formation begins before birth. Primordial germ cells complete the proliferative stage of oogenesis in the early embryonal stage when million of gamete mother cells (oogonia) are formed within each faetal ovary, no more oogonia are formed and added after birth.

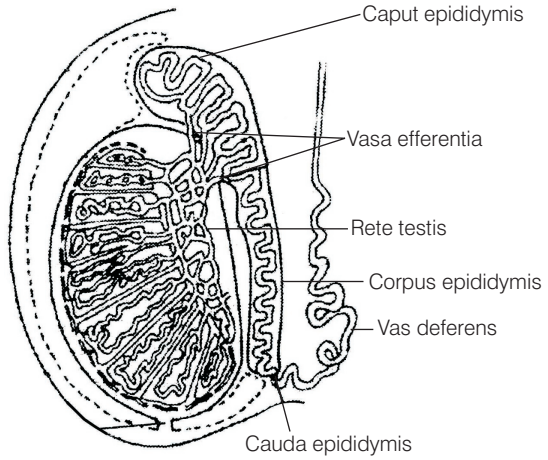
Q. 3 Spot the odd one out from the following structures with reference to the male reproductive system

(a) Rete testis
(b) Epididymis
(c) Vasa efferentia
(d) Isthmus

Ans. *(d)* Isthmus is the part of female reproductive system. The Fallopian tube (oviduct) in female reproductive system shows four regions, *i.e.*, Infundibulum, ampulla, isthmus and uterine part. Isthmus has a narrow lumen and it joins the uterus. It is the line that demacrates the body of the uterus from the cervix.



Female reproductive system showing porition of isthmus



LS of testis showing rete testis, epididymis and vasa efferantia

Q. 4 Seminal plasma, the fluid part of semen, is contributed by

I. Seminal vesicle
II. Prostate
III. Urethra
IV. Bulbourethral gland

(a) I and II
(b) I, II and IV
(c) II, III and IV
(d) I an IV

Ans. ***(b)*** The male accessory glands include paired seminal vesicles, a prostate and paired bulbourethral glands. Secretions of these glands constitute the seminal plasma which is rich in fructose, calcium and certain enzymes.

The secretions of bulbourethral glands also helps in the lubrication of the penis.

Urethra is the duct that extends through the penis in male reproductive system and serve a comman passage for both sperm and urine. In female, urethra has no reproductive function.

Q. 5 Spermiation is the process of the release of sperms from

(a) seminiferous tubules (b) vas deferens
(c) epididymis (d) prostate gland

Thinking Process

The fully developed sperms become free in the cavity of seminiferous tubules.

Ans. ***(a)*** The process of release of spermatozoa from Sertoli cells into the cavity of the seminiferous tubules is called spermiation. From here, sperms pass *via* vasa efferentia into the epididymis for temporary storage.

Q. 6 Mature Graafian follicle is generally present in the ovary of a healthy human female around

(a) 5-8 day of menstrual cycle (b) 11-17 day of menstrual cycle
(c) 18-23 day of menstrual cycle (d) 24-28 day of menstrual cycle

Thinking Process

The menstrual cycle can be divided into the following phases, i.e., menstrual phase, follicular (proliferating) phase, ovulatory phase and luteal phase.

Ans. ***(b)*** In humans (female), the menstrual cycle lasts for about 28/29 days. It is the follicular phase in which the primary follicles in the ovary grow to become a fully mature graafian follicle (due to FSH stimulation). This phase (follicular) lasts for about 14 days.

The secretion of gonadotropins (LH and FSH) increases gradually during this phase and stimulates secretion of estrogen by the growing follicles both LH and FSH attain a peak level in the middle of cycle (about 14th day).

This rapid secretion of LH called LH surge, induces rupture of Graafian follicle and thereby the release of ovum. This ovulatory phase is followed by the luteal phase during which the remaining follicular cells enlarge to become the corpus luteum.

Q. 7 Acrosomal reaction of the sperm occurs due to

(a) its contact with zona pellucida of the ova
(b) reactions within the uterine environment of the female
(c) reactions within the epididymal environment of the male
(d) androgens produced in the uterus

Thinking Process

The secondary oocyte reaching the Fallopian tube is surrounded by zona pellucida and corona radiata. A capacitated sperm passes through the corona radiata to reach the zona pellucida.

Ans. ***(c)*** One of the three glycoproteins (ZP3), functions as a sperm receptor and binds to a complementary molecule on the surface of the sperm head. Binding of the sperm head to the receptor molecule ZP3 induces the acrosome of the sperm to release its hydrolytic enzymes (sperm lysins).

The sperm lysins include

(i) Hyaluronidase, that hydrolyses hyaluronic acid of the follicular cells.

(ii) Corona penetrating enzyme dissolves corona radiata portion around the secondary oocyte by hydrolysing their ground substances.

(iii) Zona lysine or acrosin that helps to digest zona pellucida.

All these enzymes dissolve the corona radiata and zona pellucida and enable the sperm to reach the plasma membrane of the egg. The above changes in the head of sperm are called acrosome reaction.

Q. 8 Which one of the following is not a male accessory gland?

(a) Seminal vesicle (b) Ampulla

(c) Prostate (d) Bulbourethral gland

Thinking Process

The male accessory glands include paired seminal vesicles, a prostate and paired bulbourethral glands.

Ans. ***(b)*** Ampulla is one of the four region of Fallopian tubes. The oviducts (Fallopian tubes), uterus and vagina constitute the female accessory ducts. Each Fallopian tube is about 10-12 cm long and extends from the periphery of each ovary to the uterus.

The Fallopian tube shows four regions, *i.e.,* infundibulum, ampulla, isthmus and uterine part. Ampulla region is the long, wide, thin walled part next to the infundibulum.

Q. 9 The immature male germ cell undergo division to produce sperms by the process of spermatogenesis. Choose the correct one with reference to above.

(a) Spermatogonia have 46 chromosomes and always undergo meiotic cell division

(b) Primary spermatocytes divide by mitotic cell division

(c) Secondary spermatocytes have 23 chromosomes and undergo second meiotic division

(d) Spermatozoa are transformed into spermatids

Ans. ***(b)*** In testis, the immature male germ cells (spermatogonia) produce sperms by spermatogenesis. The spermatogonia present on the inside wall of seminiferous tubules multiply by mitotic division and increase in numbers.

Each spermatogonia is diploid and contains 46 chromosomes. $2n$ Some of the spermatogonia called primary spermatocytes periodically undergo meiosis. A primary spermatocyte completes the first meiotic division (reduction division) leading to formation of two equal, haploid cells called secondary spermatocytes, which have only 23 chromosomes each (n).

The secondary spermatocytes undergo the second phage of meiotic division to produce four equal, haploid spermatids. The spermatids are transformed into spermatozoa (sperms) by the process called spermiogenesis.

Q. 10 Match between the following representing parts of the sperm and their functions and choose the correct option.

	Column I		Column II
A.	Head	1.	Enzymes
B.	Middle piece	2.	Sperm motility
C.	Acrosome	3.	Energy
D.	Tail	4.	Genetic material

Codes

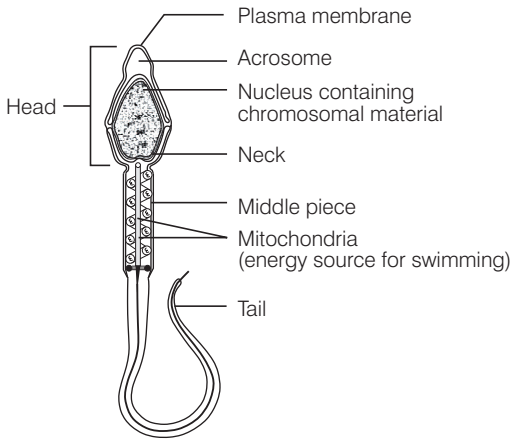
A	B	C	D		A	B	C	D
(a) 2	4	1	3	(b) 4	3	1	2	
(c) 4	1	2	3	(d) 2	1	3	4	

Ans. *(b)*

	Column I	Column II
A.	Head	Genetic material
B.	Middle piece	Energy
C.	Acrosome	Enzymes
D.	Tail	Sperm motility

The structure of a sperms composed of a head, neck, a middle piece and a tail. The sperm head contains an elongated haploid nucleus, the anterior portion of which is covered by a cap-like structure, acrosome. The acrosome is filled with enzymes that help in fertilisation of the ovum.

The middle piece possesses numerous mitochondria, which produce energy for the movement of tail that facilitate sperm motility essential for fertilisation.



Structure of a sperm

Q. 11 Which among the following has 23 chromosomes?

(a) Spermatogonia (b) Zygote
(c) Secondary oocyte (d) Oogonia

Ans. *(c)* Secondary oocyte has 23 chromosomes as it is a product of meiotic division of primary oocyte during oogenesis in the ovary. Oogenesis is initiated at the foetal ovary in the early embryonic stage of female and a fixed number of oogonia (gamete mother cells) are formed at before the birth of the female child no more oogonia are added after birth.

Spermatogonia is the immature male germ cells that produce sperms. Each spermatogonium is diploid (2*n*) and contain 46 chromosomes.

The haploid nucleus of the sperms and that of the ovum fuse together to form a diploid (2*n*) **zygote** *i.e.,* 46 chromosomes.

During foetal development, certain cells in the germinal epithelium of the ovary undergo mitotic divisions, producing undifferentiated germ cells called oogonia. The oogonia is diploid (2*n*) and contains 46 chromosomes.

Q. 12 Match the following and choose the correct options.

Column I	Column II
A. Trophoblast	1. Embedding of blastocyst in the endometrium
B. Cleavage	2. Group of cells that would differentiate as embryo
C. Inner cell mass	3. Outer layer of blastocyst attached to the endometrium
D. Implantation	4. Mitotic division of zygote

Codes

A	B	C	D		A	B	C	D
(a) 2	1	3	4	(b) 3	4	2	1
(c) 3	1	2	4	(d) 2	4	3	1

Ans. ***(b)***

Column I	Column II
A. Trophoblast	Outer layer of blastocyst attached to the endometrium
B. Cleavage	Mitotic division of zygote
C. Inner cell mass	Group of cell that would differentiate as embryo
D. Implantation	Embedding of blastocyst in the endometrium

Q. 13 Which of the following hormones is not secreted by human placenta?

(a) hCG (b) Estrogens

(c) Progesterone (d) LH

Ans. ***(d)*** LH-Luteizing Hormone is produced by anterior pituitary gland. The placenta is an organ that connects the developing embryo (foetus) and maternal body (uterine wall) to allow nutrient uptake, waste elimination and gas exchange *via* the mother's blood supply.

Placenta also acts as an endocrine tissue and produces several hormones like **Human Chorionic Gonadotropin** (hCG), Human Placental Lactogen (hPL), **estrogens, progesterone, etc.**

Q. 14 The vas deferens receives duct from the seminal vesicle and opens into urethra as

(a) epididymis (b) ejaculatory duct

(c) efferent ductule (d) ureter

Thinking Process

The male sex accessory ducts include rete testis, vasa efferentia, epididymis and vas deferens.

Ans. ***(b)*** The vas deferens is a continuation of the cauda epididymis (tail part of epididymis). It is about 40 cm long and slightly coiled at first but becomes straight as it enters the abdominal cavity through the inguinal canal.

Here, it passes over the urinary bladder, curves round the ureter and joins a duct from seminal vesicle and opens into urethra as the ejaculatory duct. These ducts store and transport the sperms from the testis to the outside through urethra.

Q. 15 Urethral meatus refers to the

(a) urinogenital duct
(b) opening of vas deferens into urethra
(c) external opening of the urinogenital duct
(d) muscles surrounding the urinogenital duct

Ans. ***(c)*** The urethra originates from the urinary bladder and extends through the penis to its external opening called urethral meatus. Opening of vas deferens along with a duct of seminal vesicle open into urethra as the ejaculatory duct.

Q. 16 Morula is a developmental stage

(a) between the zygote and blastocyst
(b) between the blastocyst and gastrula
(c) after the implantation
(d) between implantation and parturition

Ans. ***(a)*** The haploid nucleus of the sperms and that of the ovum fuse together to form a diploid zygote. As the zygote moves through the isthmus of the oviduct towards the uterus, the mitotic division (cleavage) starts and forms 2, 4, 8, 16 daughter cells called blastomeres.

The embryo with 8 -16 blastomeres is called a morula. The morula continues to divide and transforms into blastocyst as it moves further to get embedded in the endometrium of the uterus. This is called implantation.

Q. 17 The membranous cover of the ovum at ovulation is

(a) corona radiata (b) zona radiata (c) zona pellucida (d) chorion

Ans. ***(a)*** The ovum is enclosed by the inner thin, transparent, non-cellular coat zona pellucida and outer thick coat corona radiata. During fertilisation sperm first comes in contact with the corona radiata and zona pellucida to reach the plasma membrane of the egg (ovum).

Q. 18 Identify the odd one from the following

(a) labia minora (b) fimbriae (c) infundibulum (d) isthmus

Ans. ***(a)*** The female accessory ducts constitute the oviducts (Fallopian tubes), uterus and vagina. Each Fallopian tube extends from the periphery of each ovary to the uterus. The part closer to the ovary is the funnel-shaped infundibulum.

The edges of the infundibulum possess finger-like projections called fimbriae. The infundibulum leads to a wider part of the oviduct called ampulla. The last part of the oviduct is isthmus. While, labia minora is the female external genitalia.

Very Short Answer Type Questions

Q. 1 Given below are the events in human reproduction. Write them in correct sequential order.

Insemination, gemetogenesis, fertilisation, parturition, gestation, implanation.

Thinking Process

Humans reproduce sexually and give birth to young babies.

Ans. *The reproductive events in humans include*

(i) **Gametogenesis** Formation of gemetes (sperm in males, ova in females).

(ii) **Insemination** Transfer of sperm into female reproductive tract.

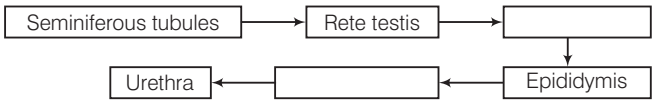
(iii) **Fertilisation** Fusion of male and female gemetes.

(iv) **Implantation** Formation, development and then attachment of blastocyst to the uterine wall.

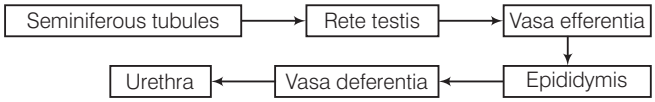
(v) **Gestation** Embryonic development inside female body.

(vi) **Parturition** Delivery of the baby.

Q. 2 The path of sperm transport is given below. Provide the missing steps in blank boxes.



Ans.



The seminiferous tubules of the testes open into the vasa efferentia through rete testis. The vasa efferentia leave the testes and open into epididymis located along the posterior surface of each testes. The epididymis leads to vas deferens that ascends to the abdomen and loops over the urinary bladder.

It receives a duct from seminal vesicle and opens into urethra as the ejaculatory duct. These ducts store and transport the sperms from the testes to the outside through urethra.

Q. 3 What is the role of cervix in the human female reproductive system?

Thinking Process

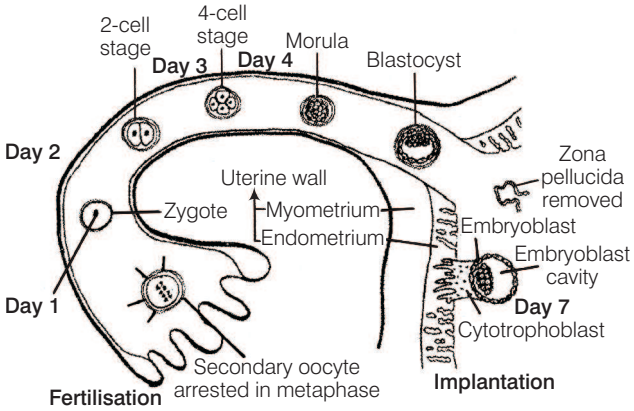
The uterus (womb) is a large, pyriform, highly elastic sac specialised for the development of the embryo. It shows four regions, fundus, body, isthmus and cervix.

Ans. (i) The **fundus** is the broad, curved, dome-shaped upper area that receives the Fallopian tubes.

(ii) The **body** is the main part of the uterus, that starts directly below the level of the Fallopian tubes and continues downward until the uterine walls and cavity begin to narrow.

(iii) The **isthmus** is the lower, narrow neck region.

(iv) The **cervix** is the lowest part that extends downward from the isthmus until it opens into the vagina.



Q. 4 Why are menstrual cycles absent during pregnancy?

Ans. The menstrual flow results due to breakdown of endometrial lining of the uterus and its blood vessels which forms liquid that comes out through vagina. Menstruation only occurs if the released ovum is not fertillised.

During pregnancy, all events of the menstrual cycle stop and the corpus luteum secretes large amounts of progesterone which is essential for the maintenance of the endometrium. These changes lead to no menstruation, during pregnancy.

Note *Lack of menstruation may be indicative of pregnancy. However, it may also be caused due to some other underlying causes like stress, poor health, etc.*

Q. 5 Female reproductive organs and associated functions are given below in column I and II. Fill the blank blanks.

Column I	Column II
Ovaries	Ovulation
Oviduct	*A*
B	Pregnancy
Vagina	Birth

Ans.

Column I	Column II
Ovaries	Ovulation
Oviduct	Fertilisation
Uterus	Pregnancy
Vagina	Birth

The female reproductive system consists of a pair of ovaries, a pair of Fallopian tubes (oviducts), uterus, vagina, external genitalia and mammary glands.

The ovaries have both an exocrine function (production of ova) and an endocrine function (secretion) of female sex hormones.

The oviduct (Fallopian tube) conveys the egg from the ovary to the uterus, and also provides the appropriate environment for its fertilisation. The uterus (womb) is a large, inverted, pear-shaped, elastic sac specialised for the development of the embryo.

The vagina is adapted for receiving the penis during copulation, allowing menstrual flow and serving as the birth canal during parturition

Q. 6 From where the parturition signals arise-mother or foetus? Mention the main hormone involved in parturition.

Ans. Parturition is induced by a complex neuroendocrine mechanism. The signals for parturition originate from the fully developed foetus and the placenta which induce mild uterine contractions called foetal ejection reflex.

The hormone involved in parturition is oxytocin that acts on the uterine muscle and causes stronger uterine contractions. This leads to the expulsion of the baby out of the uterus through the birth canal.

Q. 7 What is the significance of epididymis in male fertility?

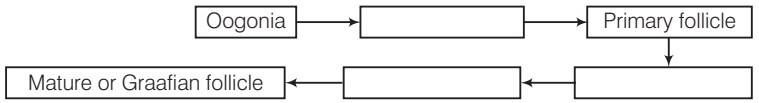
Ans. The epididymis helps the sperm in attaining maturity, acquiring increased motility and fertilising capacity. It also stores sperms for a short period before entering the vasa deferens. The epididymis shows peristatic and segmenting contractions at intervals to push the sperm away from the testis.

Q. 8 Give the names and functions of the hormones involved in the process of spermatogenesis. Write the names of the endocrine glands from where they are released.

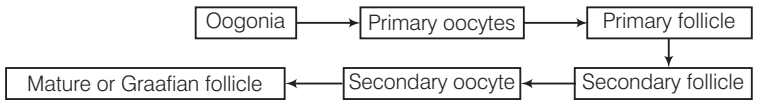
Ans. *Hormones involved in spermatogenesis are*

Hormone	Function	Gland
Gonadotrophin releasing hormone (GnRH)	Acts on pituitary to secrete LH and FSH.	Hypothalamus
Luteinizing Hormone (LH)	Acts on Leydig cells and stimulates synthesis and secretion of androgens	Pituitary
Androgens	Stimulate process of spermatogenesis	Testis
Follicle Stimulating Hormone (FSH)	Acts ons sertoli cell and stimulates secretion of some factors that help in process of spermiogenesis	Pituitary

Q. 9 The mother germ cells are transformed into a mature follicle through series of steps. Provide the missing steps in the blank boxes.



Ans.



The germinal epithelial cells divide repeatedly until many diploid **oogonia** are formed. The oogonia grow to form **primary oocytes**. Each primary oocyte then gets surrounded by a layer of granulosa cells and then called the **primary follicle**. The primary follicles get surrounded by more layers of granulosa cells and called **secondary follicles**.

The secondary follicle soon transforms into a **tertiary follicle** which is characterised by a fluid filled cavity called antrum. The primary oocyte within the tertiary follicle undergoes meiotic division to become a **secondary oocyte** and a first **polar body** (haploid).

The tertiary follicle further changes into the mature follicle or **Graafian follicle**. The Graafian follicle now ruptures to release the secondary oocyte (ovum) from the ovary by the process called ovulation.

Q. 10 During reproduction, the chromosome number ($2n$) reduces to half (n) in the gametes and again the original number ($2n$) is restored in the offspring. What are the processes through which these events take place?

Thinking Process

Gametes are haploid while zygotes are diploid.

Ans. The meiotic cell division reducers the chromosome numbers to half during gametogenesis and diploid ($2n$) number of chromosome is restored by the union of male and female gamete through process of fertilisation.

Q. 11 What is the difference between a primary oocyte and a secondary oocyte?

Ans. Primary oocyte is a diploid cell formed in foetal ovary when the gamete mother cell, oogonia is arrested at prophase-I of meiosis. Secondary oocyte is the haploid cell formed from primary oocyte that completes its first meiotic division, during puberty and produces the female gamete ova(n).

Q. 12 What is the significance of ampullary-isthmic junction in the female reproductive tract?

Ans. The act of fertilisation takes place in the female genital track that is at the junction of the isthmus and ampulla (ampullary - isthmic junction) of the Fallopian tube.

Note *Fertilisation can only occur if the ovum and sperms are transported simultaneously to the ampullary - isthmic junction. All copulations do not lead to fertilisation and pregnancy.*

Q. 13 How does zona pellucida of ovum help in preventing polyspermy?

Ans. When a sperm penetrates ovum, it induces changes in the membrane that make the zona pellucida layer impenetrable to additional sperms. Thus, it ensures that only one sperm can fertilise an ovum and stops polyspermy.

Q. 14 Mention the importance of LH surge during menstrual cycle.

Ans. Rapid secretion of LH leading to its maximum level during the mid menstrual cycle (14th day) called LH surge induces rupture of Graafian follicle and thereby the release of ovum (ovulation).

The ovulation (ovulatory phase) is followed by the luteal phase during which the remaining parts of the Graafian follicle transform as the **corpus luteum**. The corpus luteum secretes large amounts of progesterone which is essential for maintenance of the endometrium. Such an endometrium is necessary of implantation of the fertilised ovum and other events of pregnancy.

Q. 15 Which type of cell division forms spermatids from the secondary spermatocytes?

Ans. The secondary spermatocytes undergo the second meiotic division to produce four equal, haploid spermatids.

Note *Secondary spermatocytes are produced, when the primary spermatocytes undergo the first meiotic division (reduction division).*

Short Answer Type Questions

Q. 1 A human female experiences two major changes, menarche and menopause during her life. Mention the significance of both the events.

Ans. In human beings, initiation of menstruation at puberty (between age 9-15 years) is called menarche. While, menstrual cycles ceases around 50 years of age, that is termed as menopause. Menarche signifies the maturation and readiness of the female reproductive system for child bearing.

It marks the capability of the ovaries to produce mature oocyte (female gamete) that can now be fertilised by the sperm and also that the uterus is capable of supporting the foetal growth and development.

Menopause signifies the end of child bearing age. At this age supply of healthy eggs is very low, the levels of the hormones secreted by the ovaries decline and the menstruation stops. The uterus no longer remains conductive for foetal growth.

Q. 2 (a) How many spermatozoa are formed from one secondary spermatocyte?
(b) Where does the first cleavage division of zygote take place?

Thinking Process

In testis, the spermatogonia (immature germ cells) present in the form of germinal layer on the inner wall of seminiferous tubules multiply by mitotic division and increase in numbers. Each spermatogonium is diploid and contains 46 chromosomes. Some of them periodically undergo meiosis and are called primary spermatocytes.

Ans. **(a)** A primary spermatocyte completes the first meiotic division (reduction division) leading to formation of two equal, haploid cells called secondary spermatocytes ($n = 23$ chromosomes each). The secondary spermatocytes undergo the second meiotic division to produce four equal, haploid spermatids (n)., each spermatids produce spermatazoa.

(b) The mitotic division called cleavage starts 30 h after fertilisation when as to the zygote moves through the isthmus the Fallopian tube (oviduct) towards the uterus and forms blastomeres.

Q. 3 Corpus luteum in pregnancy has a long life. However, if fertilisation does not take place, it remains active only for 10-12 days. Explain.

Ans. The ruptured Graafian follicle transform into the corpus luteum and secretes large amounts of progesterone which is essential for the maintenance of the endometrium. Such an endometrium is required for the implantation of fertilised ovum (blastocyst) and other events of pregnancy.

That's why corpus luteum in pregnancy has a long life. But in the absence of fertilisation, maintenance of endometrium is not required. Therefore, corpus luteum degenerates with in 10-12 days.

Q. 4 What is foetal ejection reflex? Explain how it leads to parturition?

Ans. Foetal ejection reflex encompasses the mild uterine contractions in response to the signals that originate from the fully developed foetus and the placenta. This triggers release of oxytocin from maternal pituitary. Oxytocin acts on the uterine muscle and causes stronger contractions, which in turn stimulates further secretion of oxytocin.

The stimulatory reflex between the uterine contraction and oxytocin secretion continues resulting in stronger and stronger contractions leading to the expulsion of baby out of uterus through birth canal.

Q. 5 Except endocrine function, what are the other functions of placenta.

Ans. Placenta is structural and functional unit between developing embryo (foetus) and maternal body.

Placenta acts as an endocrine tissue and produces several hormones like human Chorionic Gonadotropin (hCG), human Placental Lactogen (hPL), estrogens, progesterones, etc.

Other than the endocrine function, placenta also facilitates the supply of oxygen and nutrients to the embryo and removes carbon dioxide and excretory/waste materials produced by the developing faetus..

Q. 6 Why doctors recommend breast feeding during initial period of infant growth?

Ans. The milk produced during the initial few days of lactation is called **colostrum** which contains several antibodies (especially 1gA) essential to develop resistance in the new-born babies against diseases. Breast-feeding during the initial period of infant growth is recommended by doctors for bringing up a healthy baby.

Q. 7 What are the events that take place in the ovary and uterus during follicular phase of the menstrual cycle.

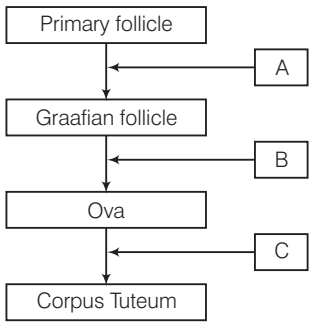
Ans. The major events of the menstrual cycle are **menstrual phase**, **follicular phase, ovulatory phase** and **luteal phase**.

The follicular phase follows the menstrual phase. During this phase, the primary follicles in the ovary grow to become a fully mature Graafian follicle and simultaneously the endometrium of uterus regenerates through proliferation. These changes in the ovary and the uterus are induced by changes in the levels of pituitary and ovarian hormones.

The secretion of gonadotropins (LH and FSH) increases gradually during the follicular phase and stimulates follicular development as well as secretion of estrogens by the growing follicles.

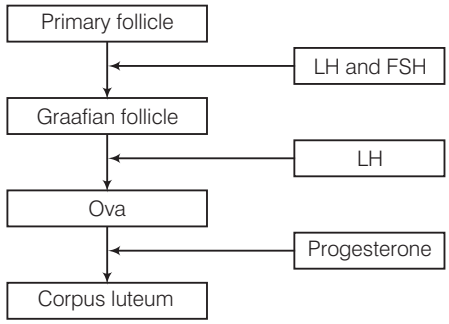
Both LH and FSH attain a peak level in the middle of cycle (about 14th day). This rapid secretion of LH leading to its maximum level induces rupture of Graafian follicle to release ovum.

Q. 8 Given below is a flow chart showing ovarian changes during menstrual cycle. Fill in the spaces giving the name of the hormones responsible for the events shown.



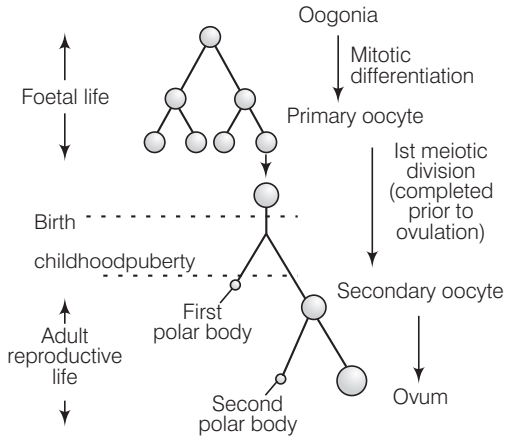
Ans. The secretion of gonadotropins (LH and FSH) increases gradually during the follicular phase and stimulates follicular development as well as secretion of estrogens. Rapid secretion of LH leading to its maximum level during the midcycle (14th day) of menstrual cycle induces rupture of Graafian follicle to release ovum.

The remaining parts of the Graafian follicle transform into the corpus luteum. The corpus luteum secretes large amounts of progesterone which is essential for maintenance of the endometrium during pregnancy.



Q. 9 Give a schematic labelled diagram to represent oogenesis (without descriptions).

Ans.



Schematic representation of oogenesis

Q. 10 What are the changes in the oogonia during the transition of a primary follicle to Graafian follicle?

Ans. The germinal epithelial cells divide repeatedly until many diploid oogonia are formed. The oogonia grow to form primary oocytes. Each primary oocyte then gets surrounded by a layer of granulosa cells and then called the primary follicle.

The primary follicles get surrounded by more layers of granulosa cells and called secondary follicles. The secondary follicle soon transforms into a tertiary follicle which is characterised by a fluid filled cavity called **antrum**.

The primary oocyte within the tertiary follicle undergoes meiotic division to become a secondary oocyte and a first polar body (haploid). The tertiary follicle further changes into the mature follicle or Graafian follicle that ruptures to release the secondary oocyte (ovum) from the ovary by the process called ovulation.

Long Answer Type Questions

Q. 1 What role does pituitary gonadotropins play during follicular and ovulatory phases of menstrual cycle? Explain the shifts in steroidal secretions.

Thinking Process

The major events of the menstrual cycle include menstrual phase, follicular phase, ovulatory phase and luteal phase.

Ans. **Menstrual Phase** (1-5 days)

Endrometrium breaks down the cell of endometrium secretions unfertilised ovum constitute menstrual flow. Progesteron production is reduced

Follicular Phese (6-13 days)

Endometrium rebuilds, FSH and oestrogen secretion is increased.

Ovulatory Phase (14-16 days)

Both LH and FSH attain peak level. Estrogen level is also high. It leads to ovulation.

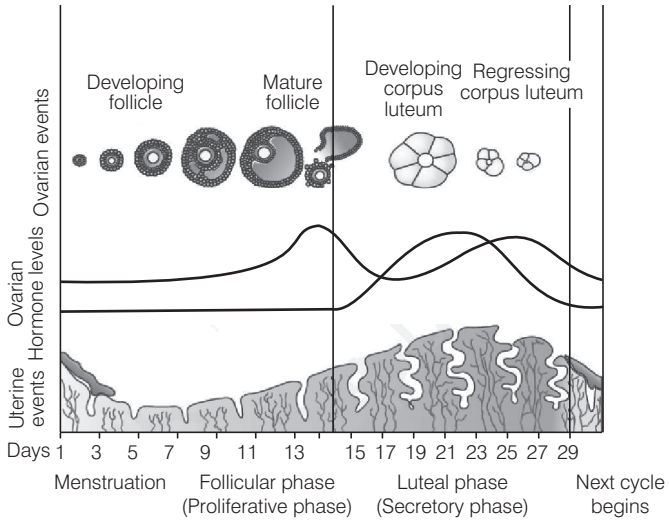
Luteal Phase (16-28 days)

In absence of fertilisation corpus luteum secretes progesterone. Endometrium Thickens and uterine glands become secretary.

The menstrual cycle starts with the menstrual phase, when menstrual flow occurs and it lasts for 3-5 days. It results due to breakdown of endometrial lining of the uterus and its blood vessels.

Follicular Phase The menstrual phase is followed by the follicular phase.

During this phase, the primary follicles in the ovary grow to become a fully mature Graafian follicle and simultaneously the endometrium of uterus regenerates through proliferation. These changes in the ovary and the uterus are induced by changes in the levels of pituitary and ovarian hormones.



Diagrammatic presentation of various events during a mentrual cycle

The secretion of gonadotropins (LH and FSH) increases gradually during the follicular phase and stimulates follicular development as well as secretion of estrogens by the growing follicles. Both LH and FSH attain a peak level in the middle of cycle (about 14th day).

Rapid secretion of LH leading to its maximum level during the mid-cycle called LH surge induces rupture of Graafian follicle and thereby the release of ovum (ovulation). The ovulation (ovulatory phase) is followed by the luteal phase during which the remaining parts of the Graafian follicle transform as the corpus luteum. The corpus luteum secretes large amounts of progesterone which is essential for maintenance of the endometrium.

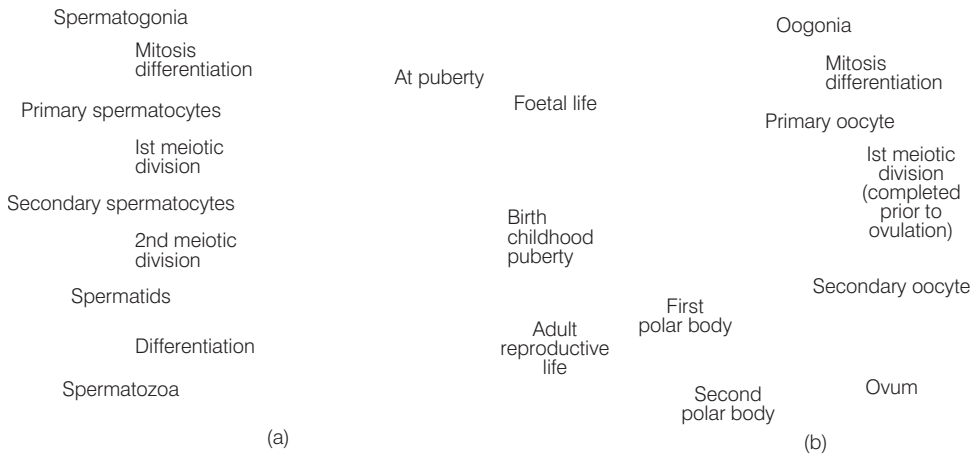
Such an endometrium is necessary for implantation of the fertilised ovum and other events of pregnancy. In the absence of fertilisation, the corpus luteum degenerates.

This causes disintegration of the endometrium leading to menstruation.

Q. 2 Meiotic division during oogenesis is different from that in spermatogenesis. Explain how and why?

Ans. *Oogenesis is different from that of spermatogenesis in the following aspects*

Spermatogenesis	Oogenesis
Sperm generation starts at puberty.	Oocytes generated before birth.
Many millions generated at a time.	Only one matures at a time, every month.
After two complete meiotic divisions, four equal sized cells produced.	Meiosis-I get arrested at prophase-I and when completed at later stage, one big cell with almost all the cytoplasm and three very small sized cells produced.
They mature into flagellated and motile cell.	Mature ovum is non-flagellated and non-motile.



Schematic representation of (a) Spermatogenesis (b) Oogenesis

Reasons

(i) Unequal cell division makes the ovum much larger than the other three polar bodies. Because ovum has more cytoplasm and more organelles, it has a better chance of surviving.

(ii) The male makes millions of tiny sperms while, the female makes only one egg per month that also waits for second meiotic division, until just before fertilisation. This is a way of conserving energy.

(iii) Sperm is smaller and motile as it has to move out of male system to female reproductive system. Larger egg has abundant reserve food so that embryo starts developing right after fertilisation.

Q. 3 The zygote passes through several developmental stages till implantation. Describe each stage briefly with suitable diagrams.

Thinking Process

The zygote undergoes mitotic division (cleavage) as it moves through isthmus of oviduct towards uterus and forms 2, 4, 8, 16 daughter cells called blastomeres.

Ans. *The zygote passes through the following stages till implantations*

(i) The embryo with 8-16 blastomeres is called a morula.

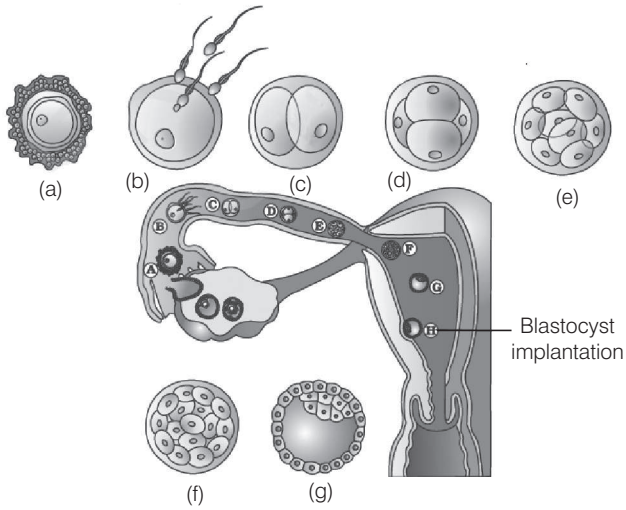
(ii) The morula continues to divide and transforms into blastocyst as it moves further into uterus.

(iii) The blastomeres in the blastocyst are arranged into a surface layer called trophoblast and a cluster of interior cells attached to trophoblast are called the inner cell mass.

(iv) The trophoblast layer then gets attached to the endometrium and inner mass cells get differentiated as embryo.

(v) After attachment, the uterine cells divide rapidly to cover the blastocyst.

(vi) The blastocyst becomes embedded in the uterine endometrium. This is called implantation.

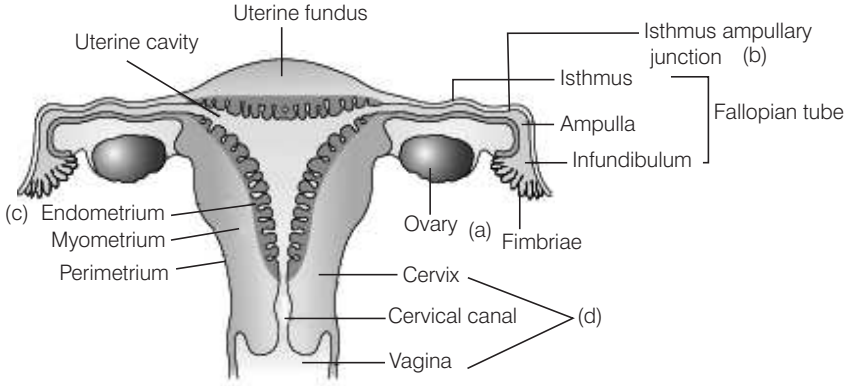


Transport of ovum, fertilisation and passage of growing embryo through Fallopian tube

Q. 4 Draw a neat diagram of the female reproductive system and label the parts associated with the following (a) production of gamete, (b) site of fertilisation (c) site of implantation and (d) birth canal.

Ans. The female reproductive system consists of a pair of ovaries along with a pair of oviducts, uterus, cervix, vagina and the external genitalia located in pelvic region.

These parts are integrated structurally and functionally to support the processes of ovulation, fertilisation, pregnancy and birth.



Diagrammatic sectional view of the female reproductive system

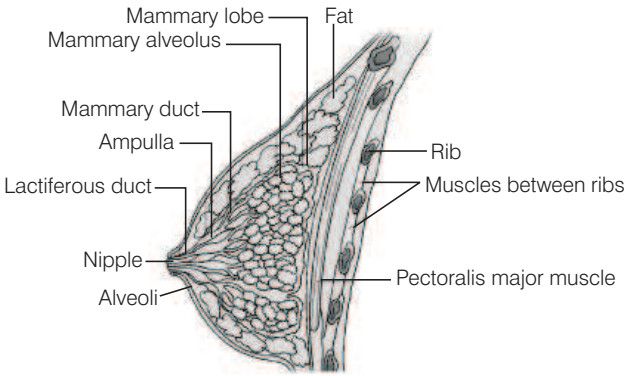
Labels

(i) Ovary (production of gamete)
(ii) Isthmus-ampullary junction(site of fertilisation)
(iii) Uterine endometrium (site of implantation)
(iv) Cervix and vagina (birth canal)

Q. 5 With a suitable diagram, describe the organisation of mammary gland.

Ans. *The description of mammary gland is as follows*

(i) The mammary glands are paired structures (breasts) that contain undeveloped duct system and adipose tissue (fat containing cells).
(ii) During pregnancy, in response to oestrogen and progesterone, a glandular system develops for milk production.
(iii) Glandular tissue of each breast develops mammary lobes containing clusters of cells called alveoli.
(iv) The cells of alveoli secrete milk, which is stored in the cavities (lumens) of alveoli
(v) The alveoli open into mammary tubules. The tubules of each lobe join to form a mammary duct.
(vi) Several mammary ducts join to form a wider mammary ampulla which is connected to lactiferous duct through which milk is sucked out by the baby.



A diagrammatic sectional view of mammary gland

2

Sexual Reproduction in Flowering Plants

Multiple Choice Questions (MCQs)

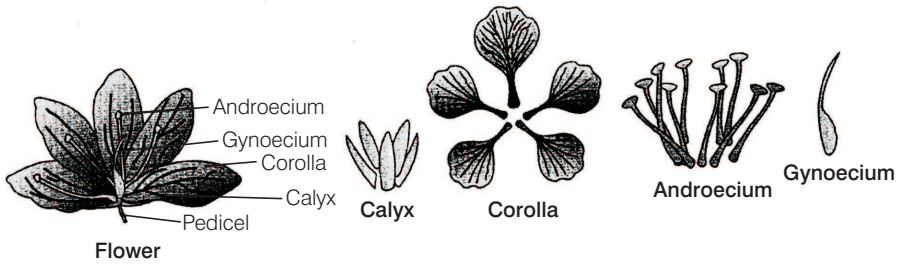
Q. 1 Among the terms listed below, those that of are not technically correct names for a floral whorl are

(i) androecium (ii) carpel

(iii) corolla (iv) sepal

(a) (i) and (iv) (b) (iii) and (iv) (c) (ii) and (iv) (d) (i) and (ii)

Ans. *(c)* All the four whorls of the plant with their relative position in flower can be indicated through following diagram.



Sepals collectively form a whorl, called as **calyx** while technically the carpel is known as gynoecium. The floral whorls formed by petals and stamens are called as **corolla** and **androecium** respectively.

Q. 2 Embryo sac is to ovule as ..... is to an anther.

(a) stamen (b) filament

(c) pollen grain (d) androecium

Thinking Process

It is the ovule within which a single Megaspore Mother Cell (MMC) differentiate into four megaspores. Out of these, only one megaspore, i.e., functional, develops into ***embryo sac*** *(female gametophyte) and the other three degenerate.*

Ans. *(c)* The pollen grains represent the male gametophytes. As the anthers mature and dehydrate, the microspores dissociate from each other and develop into pollen grains.

So, **embryo sac** is to **ovule** as **pollen grains** is to an **anther**.

Q. 3 In a typical complete, bisexual and hypogynous flower the arrangement of floral whorls on the thalamus from the outermost to the innermost is

(a) calyx, corolla, androecium and gynoecium
(b) calyx, corolla, gynoecium and androecium
(c) gynoecium, androecium, corolla and calyx
(d) androecium, gynoecium, corolla and calyx

Ans. *(a)* In a typical complete, bisexual and hypogynous flower the arrangement of floral whorls *on the thalamus from the outermost to the innermost is*

(i) The calyx, a whorl of sepals (outermost).
(ii) The corolla, a whorl of petals (inside the calyx).
(iii) The androecium, a whorl of stamens (inside the corolla).
(iv) The gynoecium, a whorl of pistils (in the centre of the flower forming inner most whorl).

Q. 4 A dicotyledonous plant bears flowers, but never produces fruits and seeds. The most probable cause for the above situation is

(a) plant is dioecious and bears only pistillate flowers
(b) plant is dioecious and bears both pistillate and staminate flowers
(c) plant is monoecious
(d) plant is dioecious and bears only staminate flowers

Thinking Process

Fertilisation of both male and female gametes is essential for the formation of fruit and seed. Usually, the male gamete constitute the motile structure while female gamete is large and non-motile.

Ans. *(d)* In dioecious plants, the unisexual male flower is staminate, *i.e.,* bearing stamens only, while the female is pistillate or bearing pistils only. For the production of fruits and seeds fertilisation must take place, which is possible only in the presence of both male and female flowers.

When the plant is dioecious, it will give rise to the following situations

(i) If the plant is dioecious and bears only pistillate flowers, fertilisation can take place with the help of pollinators.
(ii) If the plant is dioecious and bears only staminate flowers, fertilisation can't take place, because female gamete is non-motile which can't reach the male gamete in order to fuse with it.

When the plant is monoecious (*i.e.,* carryins both stamen and pistill together, it may lead to self-fertilisation and production of seed.

Q. 5 The outermost and innermost wall layers of microsporangium in an anther are respectively.

(a) Endothecium and tapetum
(b) Epidermis and endodermis
(c) Epidermis and middle layer
(d) Epidermis and tapetum

Ans. *(d)* A typical microsporangium is generally surrounded by four-wall layers, *i.e*., the epidermis, (outermost protective layer), endothecium, (middle fibraus layers) and the tapetum (innermost nutritive layer).

Q. 6 During microsporogenesis, meiosis occurs in

(a) endothecium (b) microspore mother cells
(c) microspore tetrads (d) pollen grains

Ans. ***(b)*** As the anther develops, the microspore mother cells of the sporogenous tissue undergoes meiotic divisions to form microspore tetrads. The microspore tetrad after dehydration is separated into pollen grains.

Endothecium is the layer present between epidermis and middle layer, it is formed by columner cells.

Q. 7 From among the sets of terms given below, identify those that are associated with the gynoecium.

(a) Stigma, ovule, embryo sac, placenta (b) Thalamus, pistil, style, ovule
(c) Ovule, ovary, embryo sac, **tapetum** (d) Ovule, stamen, ovary, embryo sac

Ans. ***(a)*** The gynoecium represents the female reproductive part of the flower and consists of pistil. Each pistil has three parts, *i.e.*, **stigma, style** and **ovary.** Inside the ovarian cavity, the **placenta** is located.

Arising from the placenta there are the megasporangia, commonly called **ovules.** The functional megaspore undergoing the meiotic division develops into the female gametophyte or **embryo sac**.

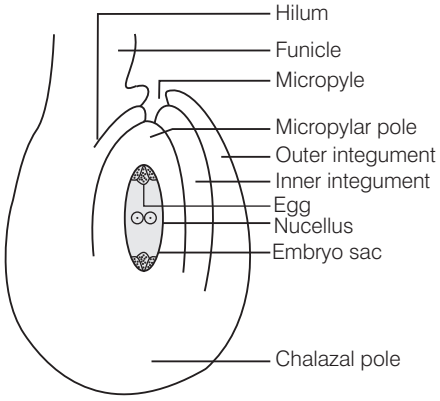
In option 'b' thalamus is not a part of gynoecium. Thalamus is the part of flower which form the base on which all the floral whorls rest upon, it is not associated with gynoecium. In option 'c' tapetum is not a part of gynoecuim.

Tapetum is the inner most nutritive layer of microsporangium and in option 'd' stamen is not a part of gynoecium. **Stamen** is male reproductive part (androecium) of plant. Therefore, the other options are wrong.

Q. 8 Starting from the innermost part, the correct sequence of parts in an ovule are

(a) egg, nucellus, embryo sac, integument
(b) egg, embryo sac, nucellus, integument
(c) embryo sac, nucellus, integument, egg
(d) egg, integument, embryo sac, nucellus

Ans. ***(b)*** Starting from the innermost part, the correct sequence of parts in an ovule is egg, embryo sac, nucellus, integument. *This sequence can be seen in following*



A diagrammatic view of an ovule

Q. 9 From the statements given below choose the option that are true for a typical female gametophyte of.

(i) It is eight-nucleate and seven-celled at maturity.

(ii) It is free-nuclear during the development.

(iii) It is situated inside the integument, but outside the nucellus.

(iv) It has an egg apparatus situated at the chalazal end.

(a) (i) and (iv) (b) (ii) and (iii)

(c) (i) and (ii) (d) (ii) and (iv)

Ans. ***(c)*** The female gametophyte or embryo sac is located inside the nucellus, enclosed within the integuments. In a majority of flowering plants, one of the megaspore is functional while the other three degenerate. Three repeated mitotic divisions of the functional megaspore results in the formation of **seven-celled** or **eight-nucleate** embryo sac.

Six of the eight nuclei are organised at the two poles. Three cells grouped at micropylar end forms **egg-apparatus** and 3 at the **chalazal end** forms **antipodal cells**. The large central cell at the centre has two polar nuclei.

The meiotic divisions in the formation of embryo sac are strictly free nuclear, that is nuclear divisions are not followed immediately by cell-wall formation. Gametophyte is situated at micropylar end not at chalazal end.

Q. 10 Autogamy can occur in a chasmogamous flower if

(a) pollen matures before maturity of ovule

(b) ovules mature before maturity of pollen

(c) both pollen and ovules mature simultaneously

(d) both anther and stigma are of equal lengths

Ans. ***(c)*** Autogamy is a method of self-pollination in which the stigma of a flower receive pollens from the anther of same flower. For autogamy both sex organs of a chasmogamous flower should mature at the same time.

As chasmogamous flowers open at maturity, pollen release and stigma receptivity should be synchronised for the process of autogamy.

In such flowers, the length of anther and stigma plays secondary role in autogamy. *e.g.,* in case of protandry (pollens mature early) and protogyny (stigma matures early) leads to cross-pollination.

Q. 11 Choose the correct statement from the following.

(a) Cleistogamous flowers always exhibit autogamy.

(b) Chasmogamous flowers always exhibit geitonogamy.

(c) Cleistogamous flowers exhibit both autogamy and geitonogamy.

(d) Chasmogamous flowers never exhibit autogamy.

Thinking Process

Chasmogamous flowers are flowers with exposed anthers and stigma and cleistogamous flowers are flowers, which do not open at all.

Ans. ***(a)*** The pollination that occurs in opened flowers is called chasmogamy. It is the most common type of pollination in all types of flowers. Chasmogamy is of two types *i.e.*, **self-pollination** (autogamy) and **cross-pollination.** Cross-pollination is of two types *i.e.*, **geitonogamy** and **xenogamy.**

So, we can say that chasmogamous flowers exhibit both autogamy (self-pollination) and allogamy (cross-pollination). While, in cleistogamous flower, the anthers and stigma lie close to each other with in the closed flowers.

When anthers dehisces in the flower buds, pollen grains come in contact with the stigma for effective pollination. Thus, these flowers are invariably autogamous as there is no chance of cross-pollen landing on the stigma.

Q. 12 A particular species of plant produces light, non-sticky pollen in large numbers and its stigmas are long and feathery. These modifications facilitate pollination by

(a) insects (b) water (c) wind (d) animals

Ans. ***(c)*** Plants use two abiotic (wind and water) and one biotic (animals) agent to achieve pollination. Majority of plants use biotic agents for pollination.

Pollination by wind is more common amongst abiotic pollination. Wind pollination requires the light and non-sticky pollen grains so that, they can be transported in wind currents.

They often possess well-exposed stamens (so that the pollens are easily dispersed into wind currents) and large often-feathery stigma to easily trap air-borne pollen grains. Wind pollination is common in grasses.

These types of pollens are not pollinated by means of other three options

(i) Pollination by water (hydrophily) is quite rare in flowering plants but accuss in aquatic plants.

(ii) Zoophihy is pollination through the agency of animals.

(iii) Entomophily is the most common type of zoophily through the agency of insects.

Q. 13 From among the situations given below, choose the one that prevents both autogamy and geitonogamy.

(a) Monoecious plant bearing unisexual flowers.

(b) Dioecious plant bearing only male or female flowers.

(c) Monoecious plant with bisexual flowers.

(d) Dioecious plant with bisexual flowers.

Ans. ***(b)*** Autogamy is a method of self-pollination in which the transfer of pollen grains from anther to stigma of the same flower takes place. While geitonogamy, is the transfer of pollen grains from anther to stigma of another flower of the same plant.

In the above condition, dioecious plants (bearing only male or female flowers) prevent both autogamy and geitonogamy. Geitonogamy is ecologically cross- pollination which is supposed to be equivalent to self-pollination because all flowers on a plant are genetically identical.

Q. 14 In a fertilised embryo sac, the haploid, diploid and triploid structure are

(a) synergid, zygote and primary endosperm nucleus

(b) synergid, antipodal and polar nuclei

(c) antipodal, synergid and primary endosperm nucleus

(d) synergid, polar nuclei and zygote

Ans. ***(a)*** (i) Synergid—haploid

(ii) Polar nuclei—haploid

(iii) Antipodal—haploid

(iv) Zygote—diploid

Since, all these cells three cells (synergid, polar nuclei and antipodals are) formed by mitosis from the functional megaspore, they are haploid (*n*).

Egg cell fertilises with the male gamete to form a diploid zygote.

(v) Primary Endosperm Nucleus (PEN).

Diploid secondary nucleus fertilises with a haploid male gamete to form a triploid PEN.

Q. 15 In an embryo sac, the cells that degenerate after fertilisation are

(a) synergids and primary endosperm cell
(b) synergids and antipodals
(c) antipodals and primary endosperm cell
(d) egg and antipodals

Ans. ***(b)*** In unfertilised embryo sac, the antipodals and synergids are distinctly present at chalazal end and micropylar end respectively While, in fertilised embryo sac antipodals and synergids gradually degenerate after the formation of zygote.

(*Also, refer to Q.* 14).

Q. 16 While planning for an artificial hybridisation programme involving dioecious plants, which of the following steps would not be relevant?

(a) Bagging of female flower
(b) Dusting of pollen on stigma
(c) Emasculation
(d) Collection of pollen

Thinking Process

Artificial hybridisation is human peformed crossing of two different plants having complementary good traits in order to obtain an overall superior variety. Two precautionary measures in artificial hybridisatian are emasculation and bagging.

Dioecious plants have the male and female reproductive organs borne on separate individuals of the same species.

Ans. ***(c)*** If the female parent produces unisexual flowers, there is no need for emasculation. The female flower buds are bagged before the flowers open.

When the stigma becomes receptive, pollination is carried out using the desired pollen and the flower rebagged. This protects them from contamination by unwanted pollen grains.

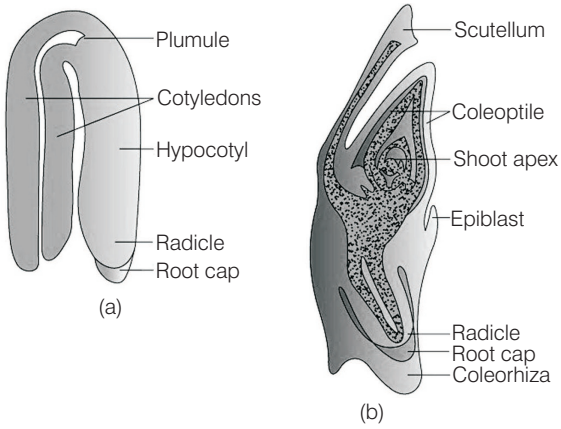
Note *If the female parent bears bisexual flowers, removal of anthers from the flower bud before the anther dehisces is necessary. This is called* ***emasculation.***

Q. 17 In the embryos of a typical dicot and a grass, true homologous structures are

(a) coleorrhiza and coleoptile
(b) coleoptile and scutellum
(c) cotyledons and scutellum
(d) hypocotyl and radicle

Ans. ***(c)*** A typical dicotyledonous embryo consists of two cotyledons.

While, embryos of monocotyledons possess only one cotyledon and it is called **scutellum** (in grass) .



(a) A typical dicot embryo
(b) LS of an embryo of grass

Q. 18 The phenomenon observed in some plants where in parts of the sexual apparatus is used for forming embryos without fertilisation is called

(a) parthenocarpy (b) apomixis
(c) vegetative propagation (d) sexual reproduction

Ans. ***(b)*** Apomixis is the phenomenon of formation of seeds without fertilisation. These embryos are genetically identical to the parental plant.

Other options are not correct because parthenocarpy and apomixis are different phenomenon. Parthenocarpy is the formation of fruits without fertilisation and hence the fruits are seedless. *e.g.,* banana.

(i) Vegetative propagatian or reproduction is a form of asexual reproduction in plants, in which new organisms arise without production of seeds or spores.

(ii) Sexual reproduction involves formation of the male and female gametes, either by the same individual or by different individuals of the opposite sex. These gametes fuse of form the zygote which develops to form the new organism.

Q. 19 In a flower, if the megaspore mother cell forms megaspores without undergoing meiosis and if one of the megaspores develops into an embryo sac, its nuclei would be

(a) haploid (b) diploid
(c) a few haploid and a few diploid (d) with varying ploidy

Thinking Process

Replacement of the normal sexual reproduction without fertilisation is called apomixis (Gk, apo- with out mixis-mixing). It does not involve meiosis.

Ans. ***(b)*** In some species, the diploid egg cell is formed without reduction division and develops into an embryo without fertilisation.

It is an asexual reproduction which occurs in the absence of pollinators or in extreme environments. In some species like citrus plants, nucellar cells surrounding the embryo sac start dividing and develops into embryos.

It occurs in the megaspore mother cell without undergoing meiosis, and produces diploid embryo sac through mitotic divisions. It helps in the preservation of desirable characters for indefinite period.

Thus, it can be concluded that apomictic species produce diploid cells. Haploid cells will be formed during sexual reproduction when cell will undergo meiosis and option 'c' and 'd' is not shown by megaspore mother cell.

Q. 20 The phenomenon wherein, the ovary develops into a fruit without fertilisation is called

(a) parthenocarpy (b) apomixis

(c) asexual reproduction (d) sexual reproduction

Ans. ***(a)*** Parthenocarpy (Gk. *parthenos*-virgin; *karpos*-fruit) is the formation of seed less fruits without fertilisation. The fruits developed from unfertilised ovary are called parthenocarpic fruits. *Other options are incorrect because*

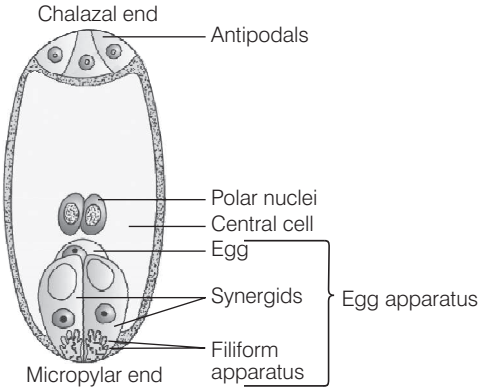
(i) In asexual reproduction, a single individual (parent) is capable of producing off spring.

(ii) For apomixis and sexual reproduction.
(*Also, refer to Q.* 18)

Very Short Answer Type Questions

Q. 1 Name the component cells of the 'egg-apparatus' in an embryo sac.

Ans. The component cells of the 'egg-apparatus' in an embryo sac include, two synergids, one egg cell and the filiform apparatus.



A diagrammatic representation of the mature embryo sac

Q. 2 Name the part of gynoecium that determines the compatible nature of pollen grain.

Thinking Process

Stigma is a part of pistil. So, somewhere it is also mentioned as the part of gynoecium that determines the compatible nature of pollen grain.

Ans. The pistil has the ability to recognise, the pollen, whether it is of the right type (compatible) or of the wrong type (incompatible). If it is of the right type, the pistil accepts the pollen and promotes post-pollination events that lead to fertilisation. If the pollen is of wrong type, the pistil rejects the pollen.

The ability of the pistil to recognise the pollen is followed by its acceptance or rejection. It is the result of a continuous dialogue between pollen grain and the pistil mediated by chemical components of the pollen interacting with those of the pistils.

Q. 3 Name the common function that cotyledons and nucellus perform.

Ans. *The common functions that cotyledons and nucellus perform are as follows*

(i) Storage of reserve food material.

(ii) **Nourishment** Cotyledons nourishes embryo and nucellus nourishes embryo sac.

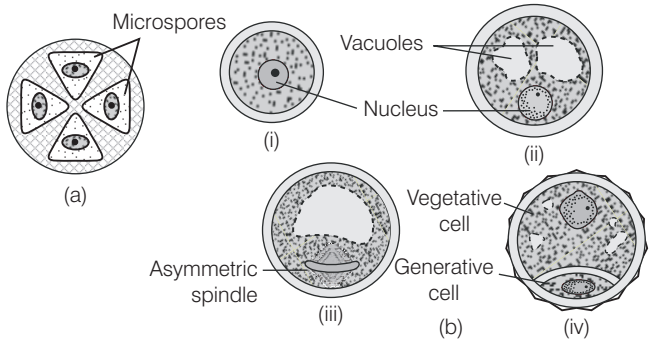
Q. 4 Complete the following flow chart

Pollen mother cell → Pollen tetrad → Pollen grain < Vegetative cell / .....

Ans. Pollen mother cell → Pollen tetrad → Pollen grain < (i) Vegetative cell / (ii) Generative cell

The process of formation of microspores from a Pollen Mother Cell (PMC) through meiosis is called microsporogenesis. The microspores, as they are formed, are arranged in a cluster of four cells *i.e.*, the **microspore tetrad**.

As the anthers mature and dehydrate, the microspores dissociate from each other and develop into **pollen grains** (male gametophyte). When the pollens mature, it contains two cells the **vegetative cell** (bigger) and **generative cell** (smaller).



Microsporogenesis : (a) A microspore tetrad

(b) A microspore maturing into a pollen grain

Q. 5 Indicate the stages where meiosis and mitosis occur (1, 2 or 3) in the flow chart.

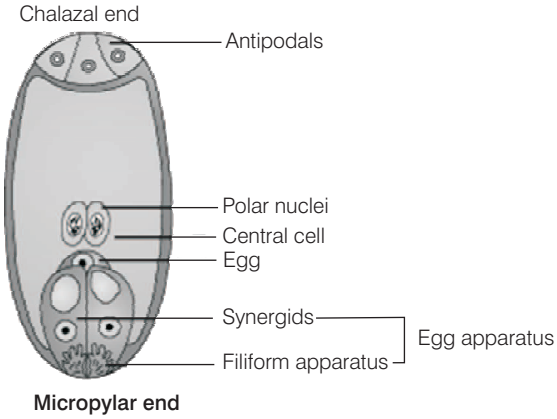
Megaspore mother cell $\xrightarrow{1}$ Megaspores $\xrightarrow{2}$ Embryo sac $\xrightarrow{3}$ Egg

Ans. Megaspore mother cell ($2n$) $\xrightarrow{\text{Meiosis}}$ Megaspores $\xrightarrow{\text{Mitosis}}$ Embryo sac (n) $\xrightarrow{\text{Meiosis}}$ Egg.

The diploid Megaspore Mother Cell (MMC) undergo meiosis and forms a linear tetrad of four haploid megaspores. Three mitotic divisions, inside the functional (one) megaspore form the embryo sac (eight haploid nuclei), while the other three megaspores degenerate.

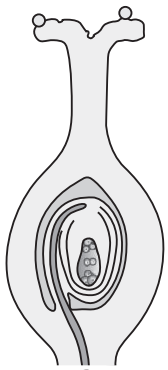
The embryo sac is a seven-celled and eight nucleated structure. Three **micropylar**, Three **chalazal** and one **central**. The three micropylar cells are collectively known as egg-apparatus, which, consists of two **synergids** and one egg cell.

While three chalazal cell form antipodal cell. The central cell is in the form of two nucleated cell till the fertilisation occurs and called as polar nuclei.



A diagrammatic representation of the mature embryo sac

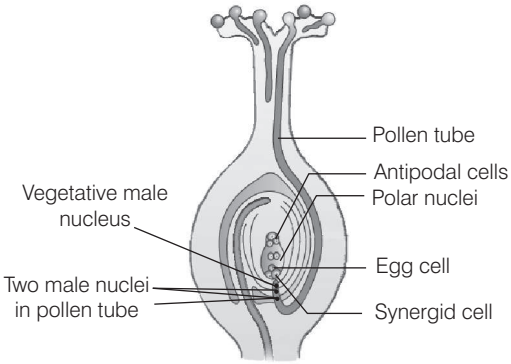
Q. 6 In the diagram given below, show the path of a pollen tube from the pollen on the stigma into the embryo sac. Name the components of egg apparatus.



Ans. Following compatible pollination, the pollen grain germinates on the stigma to produce a pollen tube through one of the germ pores. The contents of the pollen grain (2 mole nuclei) move into the pollen tube. Pollen tube grows through the tissues of the stigma and reaches the ovary.

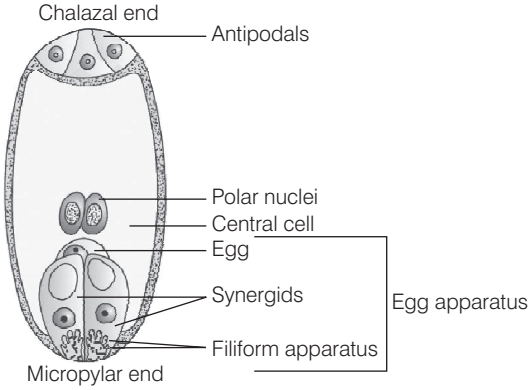
After reaching the ovary, pollen tube, enters the ovule through the micropyle and then enters the embryo sac by passing into one of the synergids through the filiform apparatus. It leads to the degeneration of that synergid.

The pollen tube breaks to release its contents (2 male nuclei). Out of the two male gametes one fuses with egg and the other fuses with central cell and fertilise.



Longitudinal section of a flower showing path of pollen tube growth

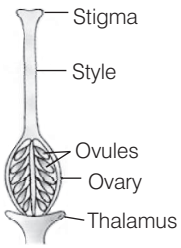
The component cells of the egg-apparatus in an embryo sac include, two synergids, one egg cell and the filiform apparatus.



A diagrammatic representation of the mature embryo sac

Q. 7 Name the parts of pistil which develop into fruit and seeds.

Ans. Pistil is the female reproductive organ that receives pollen to fertilise the egg located in ovary. A pistil has three parts, *i.e.*, **stigma** (receives pollen), which grows down through **style** to **ovary.** Ovary contains ovules, which contain an egg. The ovary develops into the fruit and ovule develops into a seeds.



Parts of a pistil

Q. 8 In case of polyembryony, if an embryo develops from the synergid and another from the nucellus which is haploid and which is diploid?

Thinking Process

Presence of more than one embryo in a seed is called ***polyembryony.*** *e.g., lemon, groundnut, etc.*

Ans. Embryo developed from the synergid is haploid as the ploidy of the synergid is haploid. Embryo developed from the nucellus is diploid as the ploidy of the nucellus is diploid.

Q. 9 Can an unfertilised, apomictic embryo sac give rise to a diploid embryo? If yes, then how?

Ans. *Yes*, if megaspore develops into embryo sac without meiotic division egg will be diploid. Diploid egg develops into embryo by mitotic divisions.

Note *Apomixis is a form of asexual reproduction to produce seeds without fertilisation.*

Q. 10 Which are the three cells found in a pollen grain when it is shed at the three celled stage?

Ans. In over 60% of angiosperms, pollen grains are shed at the two cell further stage (vegetative cell and generative cell). In the remaining species, the generative cell divides mitotically to give rise to the two male gametes before pollen grains are shed at the (three-celled stage (are vegetative cell and two male gametes).

Q. 11 What is self-incompatibility?

Ans. It is a genetic mechanism which prevents self-pollen from fertilising the ovules by inhibiting pollen germination or pollen tube growth in the pistil.

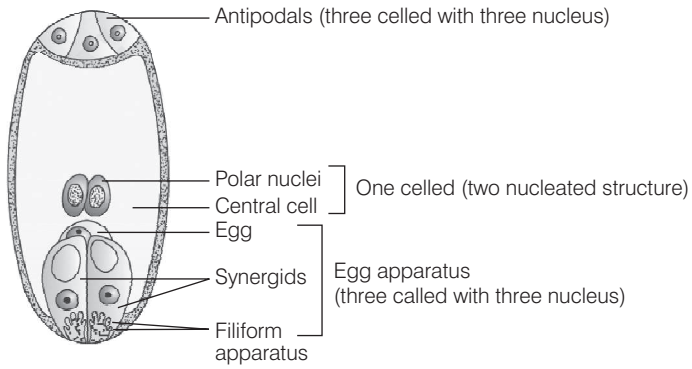
Q. 12 Name the type of pollination in self-incompatible plants.

Ans. In self-incompatible plants, (while self-pollination is incompatible) cross-pollination is occurs.

Note *Self-incompatibility is a genetic mechanism which prevents self-pollen from fertilising the ovules by inhibiting pollen germination or pollen tube growth in the pistil.*

Q. 13 Draw the diagram of a mature embryo sac and show its eight-nucleate, seven-celled nature. Show the following parts-antipodals, synergids, egg, central cell, polar nuclei.

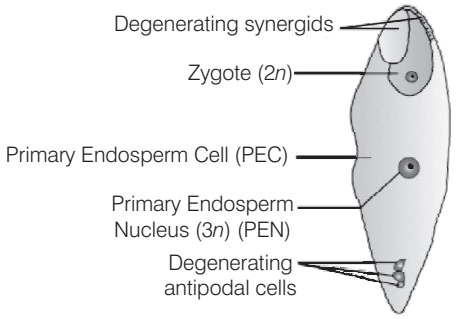
Ans.



A mature embryo sac (seven celled with eight nucleated structure)

Q. 14 Which is the triploid tissue in a fertilised ovule? How is the triploid condition achieved?

Ans. Endosperm is the triploid tissue. It results from triple fusion involving union of one male gamete and two haploid polar nuclei.



Fertilised embryo sac showing Primary endosperm nucleus (3*n*)

Q. 15 Are pollination and fertilisation necessary in apomixis? Give reasons.

Thinking Process

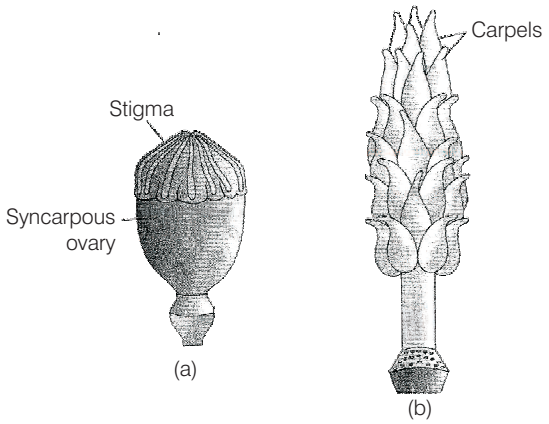
The phenomenon of asexual reproduction that mimics sexual reproduction by formation of seed without fertilisation is called apomixis.

Ans. Pollination and fertilisation are not necessary for apomixis. *The reasons in support of this are given below*

(i) Embryo sac can develop from megaspore without reduction division the egg is diploid and develops into embryo.

(ii) Embryo sac can also develop from diploid nucellus cells in which case egg is diploid that develop into embryo parthogenetically.

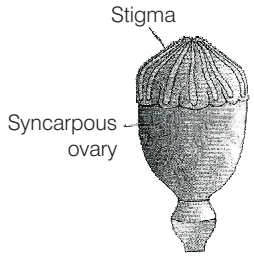
Q. 16 Identify the type of carpel with the help of diagrams given below



Thinking Process

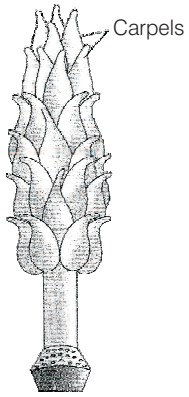
The gynoecium represents the female reproductive part of the flower and may consist of a single pistil (monocarpellary) or many pistils (multicarpellary).

Ans. **(a)** If a gynoecium has multiple carpels fused into a single structure, it is syncarpous. In this given diagram, the type of carpel is syncarpous (*e.g.,* poppy).



Multicarpellary, syncarpous pistil of *Papaver*

(b) If a gynoecium has multiple carpels in free form, it is apocarpous. In this given diagram, the type of carpel is apocarpous. (*e.g.,* michelia*)*



A multicarpellary, apocarpous gynoecium of michelia

Q. 17 How is pollination carried out in water plants?

Ans. (a) In many aquatic plants with emergent flowers, pollination occurs by wind and insects.

(b) In water plants if pollination occurs below the surface of water is called hypohydrophilly, *e.g., Ceratophyllum.*

(c) In water plants if pollination takes place over the surface of water is called epihydrophily, *e.g., Vallisneria spiralis*.

Q. 18 What is the function of the two male gametes produced by each pollen grain in angiosperms.

Thinking Process

Mature pollen grain contains two cells, the vegetative cell and generative cell. Generative cell is the generation cell that divides mitotically to give rise to the two male gametes .

Ans. One male gamete unites with egg forming embryo.This process is called fertilisation or syngamy.

Another male gamete unite with two polar nuclei resulting in the formation of endosperm triple fusion.

Short Answer Type Questions

Q. 1 List three strategies that a bisexual chasmogamous flower can evolve to prevent self-pollination (autogamy).

Thinking Process

Majority of flowering plants produce hermaphrodite flowers and pollen grains are likely to come in contact with the stigma of the same flower. This self-pollination result in inbreeding depression. Flowering plants have evolved many devices to discourage self- pollination.

Ans. A bisexual chasmogamous flower can evolve the following (three) strategies to prevent self-pollination (autogamy).

(a) **Dichogamy** In this mechanism, pollen release and stigma receptivity are not synchronised. In sunflower, the pollen is released before the stigma becomes receptive (protandry). In *Datura*, *Solanum*, the stigma becomes receptive much before the release of pollen (protogyny) leads to cross-pollination.

(b) **Herkogamy** The male and female sex organs are placed at different positions or in different directions is called Herkogamy. In these plants, the pollen cannot came in contact with the stigma of the same flower. It has undergone cross pollination, *e.g., Hibiscus, Gloriosa*.

(c) **Self-sterility** It is a genetic mechanism which prevents the self-pollen from fertilising the ovules by inhibiting pollen germination or pollen tube growth in the pistil, *e.g.,* Abotilon.

Note *Another device to prevent self-pollination is the production of unisexual flowers, but this is not beneficial as above mentioned strategies. It prevents autogamy but not geitonogamy in monoecious plants such as castor and maize.*

Q. 2 Given below are the events that are observed in an artificial hybridisation programme. Arrange them in the correct sequential order in which they are followed in the hybridisation programme (a) Re-bagging (b) Selection of parents (c) Bagging (d) Dusting the pollen on stigma (e) Emasculation (f) Collection of pollen from male parent.

Thinking Process

One of the major approaches of crop improvement programme is 'Artificial hybridisation'. In such crossing experiments it is important to make sure that only the desired pollen grains are used for pollination and the stigma is protected from contamination (from unwanted pollen).

Ans. *The correct sequential order of artificial hybridisatian is as following*

(a) Selection of parents.

(b) Emasculation (removal of anthers from the flower bud before the anther dehisces).

(c) Bagging (process to cover the emasculated flower with a bag made up of butter paper).

(d) Collection of pollen from other male plant.

(e) Dusting of pollen on stigma.

(f) Re-bagging

Note *If the female parent produces unisexual flowers, there is no need of emasculation.*

Q. 3 Vivipary automatically limits the number of offsprings in a litter. How?

Ans. Vivipary is defined as the seed germination, while the fruit is still attached to the mother plant. Plants which grow in marshy places are called **Mangroves.** In these plants when seeds fall on marshy places, they cannot germinate, because of high salinity and more water conditions.

So, in those plants, seeds germinate when they are still attached to the mother plant. Litter is the off spring at one birth of animal usually 3-8 in number.

Vivipary automatically limits the number of offspring in litter due to the reason that limited number of egg or ovum are produced and fertilised during reproductive cycle of female.

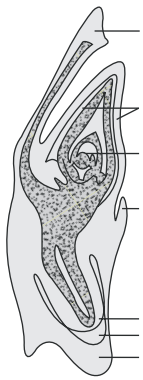
Q. 4 Does self-incompatibility impose any restrictions on autogamy? Give reasons and suggest the method of pollination in such plants.

Ans. Self-incompatibility imposes restrictions on autogamy. *The season far this may be as* Majority of flowering plants produce hermaphrodite flowers and when pollens grains comes in contact with the stigma of the same flower to continue self-pollination.

Such type of continued self-pollination result in inbreeding depression. That's why flowering plants have developed many devices to discourage self-pollination and to encourage cross-pollination. One of the major way to prevent self-pollination is self-sterility.

Self-sterility in some bisexual flowers, if the pollen grains fall on the stigma of the same flower, germination does not occur. But the same pollen grains germinate when they fall on the stigma of other flowers of the same species. It is a genetic mechanism to prevent self pollination.

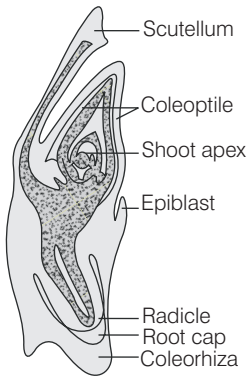
Q. 5 In the given diagram, write the names of parts shown with lines.



Ans. Embryos of monocotyledons possess only one cotyledon. In the grass family the cotyledon is called **scutellum** that is situated towards one side (lateral) of the embryonal axis.

At its lower end, the embryonal axis has the radical and root cap enclosed in an undifferentiated sheat called coleorrhiza. The portion of the embryonal axis above the level of attachment of scutellum is the epicotyl.

Epicotyl has a shoot apex and a few leaf primordia enclosed in a hollow foliar structure, the coleoptile.



LS of an manocot embryo of grass

Q. 6 What is polyembryony and how can it be commercially exploited?

Ans. Polyembryony is the occurrence of more than one embryo in a seed. In many citrus and mango varieties, some of the nucellar cells surrounding the embryo sac start dividing, protrude into the embryo sac and develop into embryos. In such species, each ovule contains many embryos.

Polyembryony plays a main role in plant breeding and horticulture. The plantlets obtained from these embryos are virus free and has more vigour. Hybrid varieties of several food and vegetable crops are being extensively cultivated and these hybrid cultivars possess high productiviy.

Q. 7 Are parthenocarpy and apomixis different phenomena? Discuss their benefits.

Ans. *Yes*, parthenocarpy and apomixis are different phenomenon.

Importance of Parthenocarpy

(i) The fruit production without fertilisation of the ovary is called **parthenocarpy.** This phenomenon is applied for the commercial production of seedless fruits. *e.g.,* banana, grapes.

(ii) This is more useful far the juice industries.

Importance of Apomixis

(i) During apomixis, chromosomal segregation and recombination does not occur. So, characters are stable for several generations.

(ii) It simplifies commercial hybridised production because isolation is not necessary to produce F_1 or maintain parental generation.

(iii) Adventive embryony is being used in the production of uniform root-stock and virus free varieties.

Q. 8 Why does the zygote begin to divide only after the division of Primary Endosperm Cell (PEC)?

Thinking Process

The zygote needs nourishment to develop.

Ans. The primary endosperm cell divides repeatedly and forms a triploid endosperm tissue. The cells of this tissue are filled with reserve food materials and are used for nutrition of the developing embryo.

Embryo develops at the micropylar end of the embryo sac where zygote is situated. Most zygotes divide only after certain amount of endosperm is formed. This is an adaptation to provide assured nutrition to the developing embryo.

Q. 9 The generative cell of a two celled pollen divides in the pollen tube, but not in a three-celled pollen. Give reasons.

Thinking Process

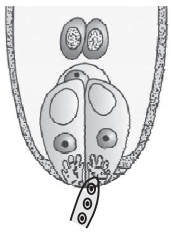
Pollen grain at maturity, divides and produce two unequal cells. The large cell is vegetative cells, has abundant food reserve and cantains a large irregular nucleus. The smaller cell is generative cell and floats in the cytoplasm of vegetative cell, which is spindle shaped with dense cytoplasm and a nucleus.

Ans. In over 60 % of angiosperms, pollen grains are shed at this 2-celled stage tube cell or vegetative cell generative cell. In the remaining species, the generative cell divides mitotically to give rise to the two male gametes before pollen grains are shed tubecell or vegetative cell two male gamete 3-celled stage.

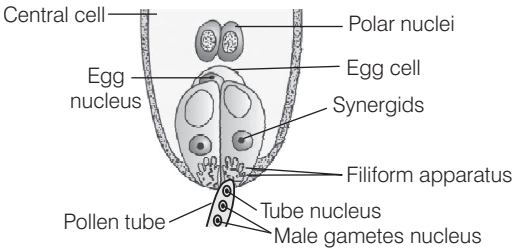
In 3 celled stage, the pollen grains further germinate on the stigma to produce pollen tube through ane of the germ pores. The contents of the pollen grains move into the tube pollen tube grows through the tissues of the stigma and style and reaches to ovary.

Inplants, when pollen grain are shed at 2 celled stage the generative cell divides and form two male gametes during the growth of the pollen tube in the stigma.

Q. 10 In the figure given below label the following parts-male gametes, egg cell, polar nuclei, synergid and pollen tube



Ans. *The following are the parts of this figure*



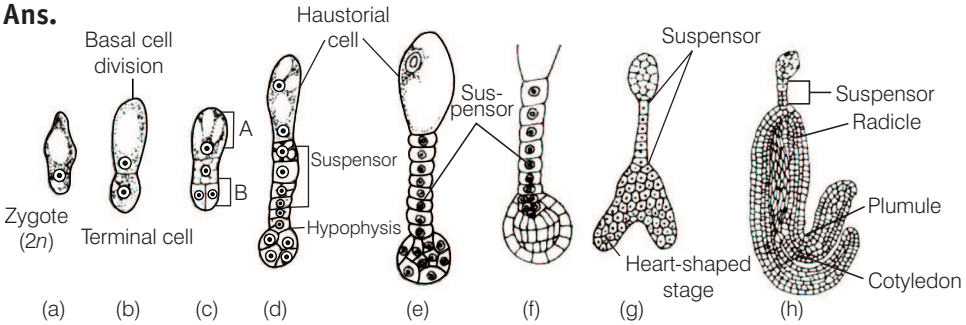
Long Answer Type Questions

Q. 1 Starting with the zygote, draw the diagrams of the different stages of embryo development in a dicot.

Thinking Process

The zygote gives rise to the proembryo and subsequently to the globular, heart-shaped and mature embryo

Ans.



Stage in the developemnt of a dicot embryo

Note *The early stages of embryogeny (embryo development) in both monocotyledons and dicotyledons are similar. In case of monocotyledonous embryo a single cotyledon is present.*

Q. 2 What are the possible types of pollinations in chasmogamous flowers. Give reasons.

Thinking Process

The pollination that occurs in open flowers is called ***chasmogamy.*** *It is the most common type of pollination in all types of flowers.*

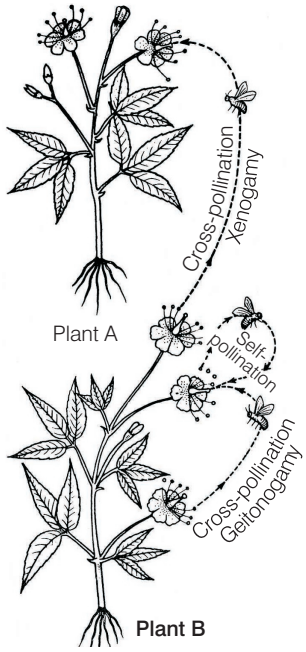
Ans. There are two types of pollinations (chasmogamy) in chasmogamous flowers, *i.e.*, self--pollination and cross-pollination.

(a) **Self-pollination**(Autogamy) The transfer of pollen grains from anther to stigma of the same flower is called **self-pollination.** It is found in both cleistogamous and chasmogamous flowers.

(b) **Cross-pollination** (Allogamy) The transfer of pollen grains from anther to stigma of another flower is called a **cross-pollination.** *It is of two types*

(i) **Geitonogamy** It is the transfer of pollen grains from anther to the stigma of another flower of the same plant. It is functionally a type of cross-pollination involving a pollinating agent, genetically. It is similar to autogamy.

(ii) **Xenogamy** The transfer of pollen grains from the flower of one plant to the stigma of another plant. This is the only type of pollination, which brings genetically different types of pollen grains to the stigma.



Showing self-pollination and cross-pollination

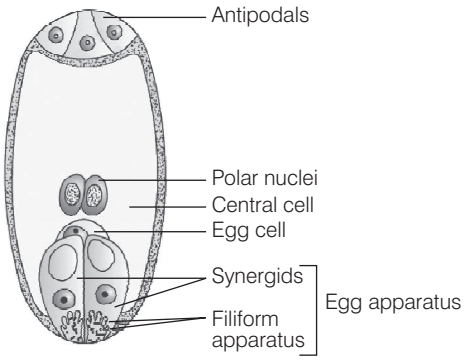
Q. 3 With a neat, labelled diagram, describe the parts of a mature angiosperm embryo sac. Mention the role of synergids.

Thinking Process

Megaspore is the mother cell for the development of female gametophyte (embryo sac). The nucleus of the functional megaspore divides mitotically to form two nuclei, which moves to the opposite poles forming two nucleus embryo sacs.

Two more mitotic nuclear divisions occur in two nuclei, resulting in the formation of eight-nucleate embryo sac.

Ans. After the 8-nucleate stage, cell walls are laid down leading to the organisation of the typical female gametophyte or embryo sac.



A mature embryo sac of angiosperm

Six of the eight nuclei are surrounded by cell walls and organised into cells. Three cells present towards the micropylar end grouped together, constitute the egg apparatus. The egg apparatus, in turn consists of two synergids and one egg cell.

Three cells of the chalazal end are called the antipodals. The large central cell is formed by the fusion of 2-polar nuclei. Thus, a typical angiospermic embryo sac, at maturity consists of eight nuclei and seven cells. This embryo sac is formed from, the single megaspore, so it is called 'monosporic embryo sac.

Role of Synergids

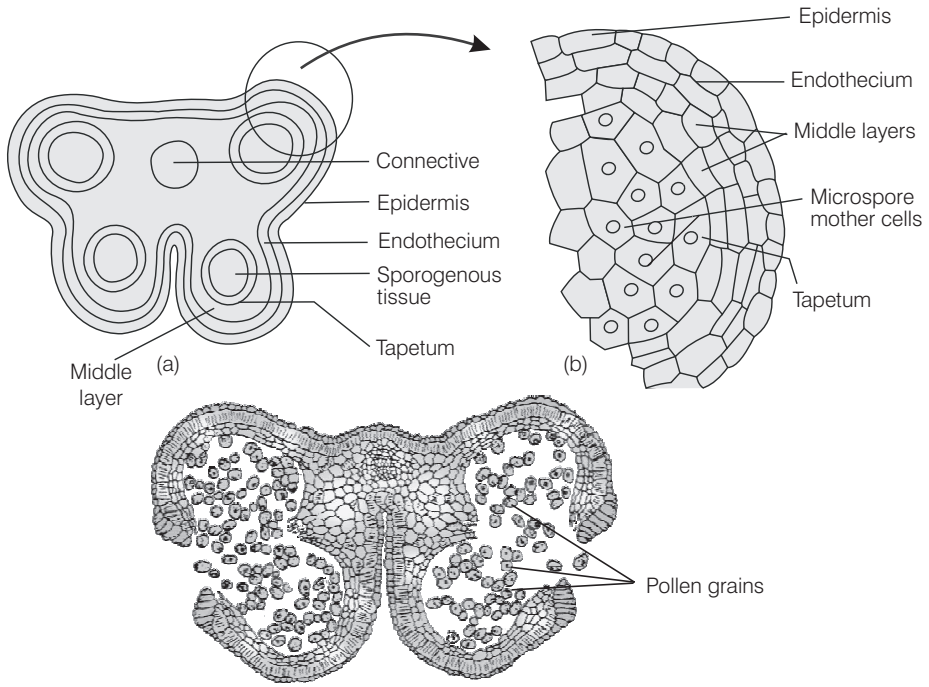
The synergids have special cellular thickenings at the micropylar tip called filiform apparatus, which play an important role in guiding the pollen tubes into the synergid.

Q. 4 Draw the diagram of a microsporangium and label its wall layers. Write briefly about the wall layers?

Thinking Process

A typical angiospermic anther is bilobed with each lobe having two theca. The anther is a four sided structure consisting of four microsporangia located at the corners, two in each lobe.

Ans. *The diagram representation of a microsporangium is shown below*



(a) Transverse section of a young anther (b) Enlarged view of one microsporangium showing wall layers (c) Mature dehisced anther showing pollen grain

In a transverse section, a typical microsporangium is circular in outline and is surrounded by four wall layers.

(a) **Epidermis** The epidermis is the outermost protective layer. It is composed of tangentially flattened cells. The cells are closely fitted and have thick walls which is helpful in the dehiscence of anther.

(b) **Endothecium** It is present below the epidermis and expands radically with fibrous thickenings, at maturity these cells loose water, at contract and help in dehiscence of pollen sac.

(c) **Wall Layers** It is present between well marked endothecium and tapetum. These are thin walled layers, arranged in one to five layers, which also help in dehiscence of anther.

(d) **Tapetum** It is the innermost wall layer with large cells, thin cell walls, abundant cytoplasm and have more than one nuclei. Tapetum is a nutritive tissue which nourishes the developing pollen grains.

The centre of the microsporangium consists of sporogenous tissue, which undergoes meiotic divisions to form microspore tetrads. This process is known as microsporogenesis.

Q. 5 Embryo sacs of some apomictic species appear normal, but contain diploid cells. Suggest a suitable explanation for the condition.

Ans. Replacement of the normal sexual reproduction by asexual reproduction without fertilisation is called apomixis. *e.g.,* replacement of the flower by bulbils and replacement of the seed by a plant.

Apomitically produced offsprings are genetically identical to the parent plant. In flowering plants, apomixis is used in a restricted sense to mean angiosperm, *i.e.*, asexual reproduction through seeds.

In some plant species it is common, *e.g.,* Asteraceae, Poaceae. In some species, the diploid egg cell is formed without reduction division and develops into embryo without fertilisation. It is an asexual reproduction in the absence of pollinators such as in extreme environments.

In some species like citrus, some of the nucellar cells surrounding the embryo sac start dividing and develop into embryo. It occurs in the megaspore mother cell does not undergo meiosis, thus produces diploid embryo sac through mitotic divisions.

Thus, it explains that, embryo sacs of some apomictic species appear normal, but produce diploid cells.

1

Reproduction in Organisms

Multiple Choice Questions (MCQs)

Q. 1 A few statements describing certain features of reproduction are given below

I. gametic fusion takes place.

II. transfer of genetic material takes place.

III. reduction division takes place.

IV. progeny have some resemblance with parents.

Select the options that are true for both asexual and sexual reproduction from the options given below

(a) I and II (b) II and III (c) II and IV (d) I and III

Thinking Process

Reproduction is a biological process in which an organism gives rise to young ones (offspring) having some resemblance with itself. If enables the continuity of the species, generation after generation.

Ans. ***(c)*** In both types of reproduction (asexual and sexual) there is transfer of genetic material from parent (s) to their young ones which have some resemblances with their parents.

Reduction division (meiosis) has to occur if a diploid body has to produce haploid gametes that is in case of sexual reproduction only.

Gametic fusion The formation of male and female gametes and their fusion to form the zygote also takes place only in the sexual reproduction.

Q. 2 The term 'clone' cannot be applied to offspring formed by sexual reproduction because

(a) offspring do not possess exact copies of parental DNA

(b) DNA of only one parent is copied and passed on to the offspring

(c) offspring are formed at different times

(d) DNA of parent and offspring are completely different

Ans. ***(a)*** The offsprings that are produced as a result of asexual reproduction are not only identical to one another but are also exact copies of their parent. So, such individuals are called clones. While, in the case of sexual reproduction DNA of both parents, (*i.e.,* male and female gametes) is copied and passed on to the offspring after fusion. The offspring, thus formed do not possess exact copies of parental DNA.

Q. 3 *Amoeba* and yeast reproduce asexually by fission and budding respectively, because they are

(a) microscopic organisms
(b) heterotrophic organisms
(c) unicellular organisms
(d) uninucleate organisms

Ans. ***(c)*** Unicellular organisms, have relatively simple organisations. So, the asexual mode of reproduction is common in them. It is so because by asexual reproduction unicellular organisms can multiply very fast. In *Amoeba* it occurs by binary fission and in yeast by budding to be described first.

In the sexual reproduction, both male and female gametes have to fuse, while in asexual reproduction, cell division takes place.

Heterotrophic organisms (humans, animals and decomposers) can reproduce either asexually or sexually, *e.g.,* in bacteria sexual reproduction occurs *via* conjugation and asexual reproduction occurs *via* binary fission.

Uninucleate organisms, like *Ulva* (algae) reproduce asexually by zoospores and sexually by the fusion of gametes.

Q. 4 A few statements with regard to sexual reproduction are given below

I. Sexual reproduction does not always require two individuals.
II. Sexual reproduction generally involves gametic fusion.
III. Meiosis never occurs during sexual reproduction.
IV. External fertilisation is a rule during sexual reproduction.

Choose the correct statements from the options below.

(a) I and IV (b) I and II
(c) II and III (d) I and IV

Ans. ***(c)*** Sexual reproduction involves formation of the male and female gametes either by the same individual (*e.g., Taenia*) or by different individuals of the opposite sex (*e.g.,* rabbit).

These gametes fuse to form the zygote which develops to form the new organism. Meiosis (reduction division) occurs only during sexual reproduction to produce haploid gametes. It is internal fertilisation which occurs during sexual reproduction. In this type egg is formed inside the female body where they fuse with the male gamete.

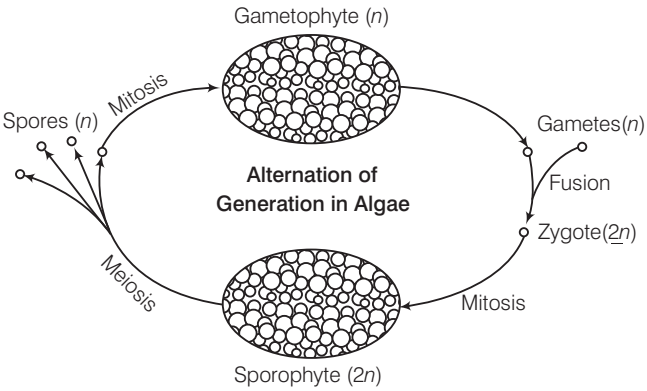
Q. 5 A multicellular, filamentous alga exhibits a type of sexual life cycle in which the meiotic division occurs after the formation of zygote. The adult filament of this alga has

(a) haploid vegetative cells and diploid gametangia
(b) diploid vegetative cells and diploid gametangia
(c) diploid vegetative cells and haploid gametangia
(d) haploid vegetative cells and haploid gametangia

Thinking Process

The literary meaning of alternation of generation is one in which one generation follows the other in alternating and repeating manner.

Ans. ***(d)*** A multicellular gametophyte (gametangia), which is haploid (*n*) alternates with a multicellular sporophyte, which is diploid (2*n*). A mature sporophyte produces spores (haploid cells) by meiosis, a process which reduces the number of chromosomes to half, from 2*n* to *n*.



Q. 6 The male gametes of rice plant have 12 chromosomes in their nucleus. The chromosome number in the female gamete, zygote and the cells of the seedling will be, respectively

(a) 12, 24, 12 (b) 24, 12, 12 (c) 12, 24, 24 (d) 24, 12, 24

Thinking Process

Gametes are formed from the meiotic division of meiocytes. In each gamete only one set of chromosomes gets incorporated.

Ans. ***(c)*** In female gamete the chromosome number will be same as that of the male gamete (12).

A zygote is a fertilised egg/seed which means gametes from the parents have been combined (diploid) and thus, the chromosome number will be 24 (2*n*).

A seedling is a young plant sporophyte developing out of a plant embryo from a seed. So, the chromosome number in the cells of the seedlings will be 24 (2*n*), which will further give rise to new diploid individual.

Q. 7 Given below are a few statements related to external fertilisation.

I. The male and female gametes are formed and released simultaneously.
II. Only a few gametes are released into the medium.
III. Water is the medium in a majority of organisms exhibiting external fertilisation.
IV. Offspring formed as a result of external fertilisation have better chances of survival than those formed inside an organism.

Choose the correct statements.

(a) III and IV (b) I and III (c) II and IV (d) I and IV

Ans. ***(b)*** External fertilisation occurs outside the body of the organism. It takes place in most aquatic organisms, such as a majority of algae and fishes as well as amphibians. Organisms exhibiting external fertilisation release a large number of gametes in the surrounding medium. (*e.g.,* water) in order to enhance the chances of syngamy.

A major disadvantage is that the offspring are extremely vulnerable to predators threatening their survival upto adulthood.

Q. 8 The statements given below describe certain features that are observed in the pistil of flowers.

I. Pistil may have many carpels.
II. Each carpel may have more than one ovule.
III Each carpel has only one ovule.
IV. Pistil have only one carpel.

Choose the statements that are true from the options below.

(a) I and II (b) I and III (c) II and IV (d) III and IV

Thinking Process

The gynoecium represents the female reproductive part of the flower. The pistil is the free unit of gynoecium. Each pistil is constructed of one to many enrolled leaf-like structures or carpels.

Ans. ***(a)*** A pistil, (one a many carpels) has three parts, *i.e.,* stigma, style and ovary. Ovary, the swollen part of the pistil contains an angiospermic, ovoid and whitish structure called ovule. Inside ovary it is attached to a parenchymatous cushion called placenta, either singly or in cluster.

Q. 9 Which of the following situations correctly describe the similarity between an angiospermic egg and a human egg?

I. Eggs of both are formed only once in a lifetime.
II. Both the angiosperm egg and human egg are stationary.
III. Both the angiosperm egg and human egg are motile transported.
IV. Syngamy in both results in the formation of zygote.

Choose the correct answer from the options given below.

(a) II and IV (b) only IV
(c) III and IV (d) I and IV

Ans. ***(b)*** In case of many terrestrial organisms (including both angiosperms and humans) which exhibit internal fertilisation, syngamy occurs inside the body of the organism to form zygote.

Both the angiosperm and human remains reproductively active throughout their reproductive phase. It means the formation of egg takes place not only once but many times in a lifetime.

In humans, once an egg has been released from ovary, the beating of cilia in the Fallopian tube moves the egg from the ovary to the uterus. So, the egg is considered as motile not stationary.

In flowering plants (angiosperms), the gametes are non-motile cells within gametophytes, but for the fusion to take place the non-motile male gametes are carried to female gamete by pollen-tubes.

Q. 10 Appearance of vegetative propagules from the nodes of plants such as sugarcane and ginger is mainly because

(a) nodes are shorter than internodes (b) nodes have meristematic cells
(c) nodes are located near the soil (d) nodes have non-photosynthetic cells

Ans. ***(b)*** Appearance of vegetative propagules from the nodes of plants such as sugarcane and ginger is mainly because of the nodes having meristematic cells.

These cells are responsible to control the growth and development of tissues and organs in plants. Nodes (present in the modified stems) when come in contact with damp soil or water, they produce roots and gives rise to new plants.

Q. 11 Which of the following statements, support the view that elaborate sexual reproductive process appeared much later in the organic evolution.

I. Lower groups of organisms have simpler body design.

II. Asexual reproduction is common in lower groups.

III. Asexual reproduction is common in higher groups of organisms.

IV. The high incidence of sexual reproduction in angiosperms and vertebrates.

Choose the correct answer from the options given below.

(a) I and III (b) I and III

(c) II and IV (d) II and III

Thinking Process

All living things are identified and categorised on the basis of their body design (structuce and function). When we connect this idea of classification to evolution we will find some organisms which have ancient body designs and have not changed much, while the other groups have acquired their particular body designs relatively recently.

Those in the first group are referred to as primitive or lower organisms, while those in the second group are called advanced or higher organisms.

Ans. ***(c)*** Asexual reproduction (budding) has been found in most primitive animals like *Hydra*, but over the evolutionary time as the higher or advanced organisms came into existence, they resorted the sexual reproduction as it ensures the genetic recombination that results in variation.

Q. 12 Offspring formed by sexual reproduction exhibit more variation than those formed by asexual reproduction because

(a) sexual reproduction is a lengthy process

(b) gametes of parents have qualitatively different genetic composition

(c) genetic material comes from parents of two different species

(d) greater amount of DNA is involved in sexual reproduction

Ans. ***(b)*** In asexual reproduction the offspring that are produced are not only identical to the parent but are also exact copies of their parent. It is because in asexual reproduction there is the involvement of a single parent. So, in this case the genetic variation is not created.

While, in sexual reproduction genetic variation is created and inherited. In sexual reproduction, two parents (opposite sex) having different genetic composition participate in the reproductive process and also involve fusion of male and female gametes, which gives rise to the new individual having genetic composition of both.

Q. 13 Choose the correct statement from amongst the following.

(a) Dioecious (hermaphrodite) organisms are seen only in animals.

(b) Dioecious organisms are seen only in plants.

(c) Dioecious organisms are seen in both plants and animals.

(d) Dioecious organisms are seen only in vertebrates.

Thinking Process

Hermaphrodite is an organism that has reproductive organs normally associated with both male and female sexes. It is the bisexual condition found in both plants (e.g., rose) and animals (e.g., snail).

Ans. ***(c)*** Dioecious is the term used to describe unisexual condition. Dioecious organisms are seen in both plants and animals.

Example of dioecious plant- *Marchantia*

Example of dioecious animal-Cockroach (invertebrate).

Q. 14 There is no natural death in single celled organisms like *Amoeba* and bacteria because

(a) they can'not reproduce sexually

(b) they reproduce by binary fission

(c) parental body is distributed among the offspring

(d) they are microscopic

Ans. ***(c)*** There is no natural death in single celled organisms like *Amoeba* and bacteria because parental body is distributed among the offspring. In such organisms, reproduction occur by cell division where a cell (parent) divides into two halves and each rapidly grows into an adult (offspring).

Q. 15 There are various types of reproduction. The type of reproduction adopted by an organism depends on

(a) the habitat and morphology of the organism

(b) morphology of the organism

(c) morphology and physiology of the organism

(d) the organism's habitat, physiology and genetic makeup

Ans. ***(d)*** There is a large diversity in the biological world and each organism has evolved its own mechanism to multiply and produce offspring. The type of reproduction adopted by an organism depends on the organism's habitat, its internal physiology and several other factors.

Q. 16 Identify the incorrect statement.

(a) In asexual reproduction, the offspring produced are morphologically and genetically identical to the parent.

(b) Zoospores are sexual reproductive structures.

(c) In asexual reproduction, a single parent produces offspring with or without the formation of gametes.

(d) Conidia are asexual structures in *Penicillium*.

Thinking Process

In asexual reproduction, a single individual (parent) is capable of producing offspring. As a result, the offsprings produced are identical to one another and also to their parent both genetically and morphologically.

Ans. ***(b)*** Asexual reproduction occurs usually in unicellular organisms by various ways like binary fission, budding, sporulation, etc. In this method, a single parent produces offspring with or without the involvement of gametes.

Members of the kingdom fungi and simple plants reproduce through special asexual reproductive structures like conidia (*Penicillium*) buds (*Hydra*) etc. The most common of these structures are zoospores that are microscopic motile structures.

All other options are correct.

Q. 17 Which of the following is a post-fertilisation event in flowering plants?

(a) Transfer of pollen grains (b) Embryo development

(c) Formation of flower (d) Formation of pollen grains

Ans. ***(b)*** Embryo development takes place after the fertilisation, *i.e.,* fusion of male and female gametes (n) result in the formation of zygote ($2n$). Thus, it is a post fertilisalion event.

Rest of the events takes place before occurrrence of fertilisation, hence are pre-fertilisation enents.

Q. 18 The number of chromosomes in the shoot tip cells of a maize plant is 20. The number of chromosomes in the microspore mother cells of the same plant shall be

(a) 20 (b) 10 (c) 40 (d) 15

Ans. ***(a)*** The whole plant body of maize plant including shoot tip cells remains in diploid ($2n$) condition. As the microspore mother cell is a part of reproductive organ, the chromosome number in these cells will remain same as the individual. *i.e.,* $2n=20$.

These microspore mother cells are further responsible for producing male gametes, *i.e.,* haploid (n) by reduction division.

Very Short Answer Type Questions

Q. 1 Mention two inherent characteristics of *Amoeba* and yeast that enable them to reproduce asexually.

Ans. The characteristics that enable *Amoeba* and yeast to reproduce asexually, *are as follows*

(i) Unicellularity (ii) Simple body organisation

(iii) Uniparental condition

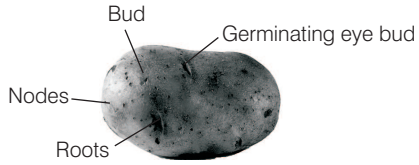
Q. 2 Why do we refer to offspring formed by asexual method of reproduction as clones?

Ans. The reproduction is called **asexual**, when offspring is produced by a single parent with or without the involvement of gamete formation.

As a result, the offspring that are produced are not only similar to one another, but are also exact copies of their parent. Such a group of morphologically and genetically similar individuals is called **clone**.

Q. 3 Although potato tuber is an underground part, it is considered as a stem. Give two reasons.

Ans. *Potato tuber is considered as a stem because of the following reasons*



(i) The tuber has nodes and internodes.

(ii) Leafy shoots appear from the nodes.

Q. 4 Between an annual and a perennial plant, which one has a shorter juvenile phase? Give one reason.

Ans. In a lifespan, the organism has to grow and develop (the juvenile phase). After that the organism mature sexually and enter into the reproductive phase, before it undergoes senescence followed by death.

Since, the entire life cycle of an annual plant is shorter and has to be completed in one growing season, its juvenile phase is shorter than that of a perennial plant.

Q. 5 Rearrange the following events of sexual reproduction in the sequence in which they occur in a flowering plant embryogenesis, fertilisation, gametogenesis, pollination.

Thinking Process

The gametes need to be formed first of all, pollination ensures their transfer, so that fertilisation can take place. Fertilised zygote divides and differentiates during embryogenesis.

Ans. The correct sequence of events of sexual reproduction in a flowering plant are as follows gametogenesis, pollination, fertilisation, embryogenesis.

Q. 6 The probability of fruit set in a self-pollinated bisexual flower of a plant is far greater than a dioecious plant. Explain.

Ans. The probability of fruit set in a self-pollinated bisexual flower of a plant is far greater than a dioecious plant.

In self-pollinated bisexual plants transfer of pollen to stigma of flowers is easier than the dioecious plants. It is so because the anther and stigma lie close to each other and pollination is not effected even in the absence of pollinator. But in dioecious plants pollinator is necessary to bring about effective pollination as the anther and stigma lie away from each other.

Q. 7 Is the presence of large number of chromosomes in an organism a hindrance to sexual reproduction? Justify your answer by giving suitable reasons.

Ans. *No*, presence of large number of chromosomes in an organism is not a hindrance to sexual reproduction. *Ophioglossum* (a fern) has chromosome number 1260, still it can reproduce sexually.

In higher organisms, the chromosomes are present in a compartment called nucleus, within the cell. Whether the number is small or large, the chromosomes are duplicated and then segregated inside this compartment, during cell division. The basis of sexual reproduction is generation of haploid gametes.

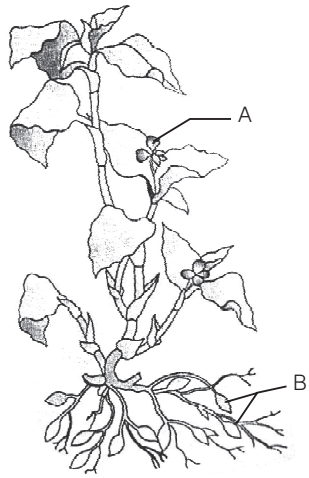
Q. 8 Is there a relationship between the size of an organism and its life span? Give two examples in support of your answer.

Ans. There is no relationship between the size and life span of an organism. *e.g.,*

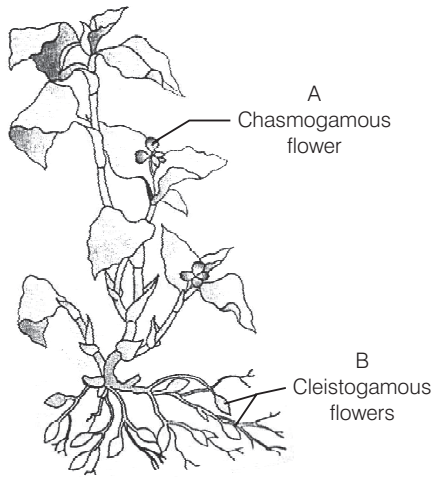
(i) The mango tree has a shorter life span as compared to a peepal tree though both are of the same size.

(ii) The size of crow and parrot is almost same but the life span is 15 years and 150 years respectively.

Q. 9 In the figure given below the plant bears two different types of flowers marked 'A' and 'B'. Identify the types of flowers and state the type of pollination that will occur in them.



Ans. *In the figure given below the plant bears folllowing two types of flowers*



A—Chasmogamous flower (the flowers remain open, exposing anthers and stigmas).

B—Cleistogamous flowers (the flowers remain closed, so that anthers and stigmas are never exposed) following are the types of pollination that will occur in these flowers.

(i) Autogamy (within same flower)

(ii) Geitonogamy (different flowers of same plant)

(iii) Xenogamy (different plants)

It is a case of cleistogamy (a type of autogamy) in which some plants, like, *Commelina bengalensis* possess both chasmogamous and cleistogamous flowers.

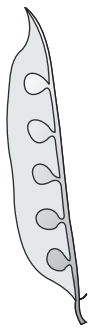
In chasmogamous flowers, the flowers may undergo self-pollination or cross-pollination, while in cleistogamous flowers, the flowers undergo only self-pollination.

Q. 10 Give reasons as to why cell division cannot be a type of reproduction in multicellular organisms.

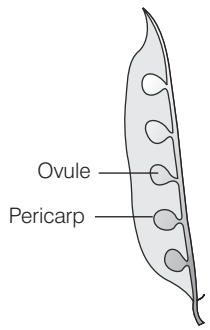
Ans. In unicellular animals, cell division is the means of reproduction to increase their number while, in case of multicellular organisms, they have well developed reproductive organs which help in reproduction.

Their whole body does not participate in reproduction like unicellular organisms.

Q. 11 In the figure given below, mark the ovule and pericarp.



Ans. In flowering plants, the zygote is formed inside the ovule. After fertilisation the sepals, petals and stamens of the flower wither and fall off. The pistil however, remains attached to the plant.



The zygote develops into the embryo and the ovules develop into the seed. The ovary develops into the fruit which develops a thick wall called pericarp that is protective in function.

Q. 12 Why do gametes produced in large numbers in organisms exhibit external fertilisation?

Thinking Process

In most aquatic organisms, such as a majority of algae and fishes as well as amphibians, syngamy (fusion of gametes in sexual reproduction) occurs in the external medium (water) , i.e., outside the body of the organism. This type of genetic fusion is called ***external fertilisation.***

Ans. *Organisms that take part in such process produce large number of gametes because*

(i) In external fertilisation, there is a great chance that the sperm and the eggs released by the organisms can be affected by factors present in the environment like dessication, predators, etc. So, to make up for the high fatality rate of the gametes, the organism produces a lot of gametes.

(ii) Producing large number of gametes increase the chance for at least some eggs and sperms to meet in the environment ensuring that atleast a stable number of offspring are able to survive and carry on.

Q. 13 Which of the following are monoecious and dioecious organisms?

(a) Earthworm ..... (b) *Chara* .....

(c) *Marchantia* ..... (d) Cockroach .....

Ans. (a) Earthworm- Monoecious animal (b) *Chara*- Monoecious plant

(c) *Marchantia*-Dioecious plant (d) Cockroach- Dioecious animal

Note *In several fungi and plants, terms such as* ***homothallic*** *and* ***monoecious*** *are used to denote the* ***bisexual condition*** *(male and female reproductive structures in the same plant) and* ***heterothallic and dioecious*** *are the terms used to describe* ***unisexual condition*** *(male and female reproductive structures on different plants).*

But in animals, individuals are either male or female (unisexual) or possess both the reproductive organs (bisexual).

Q. 14 Match the organisms given in column I with the vegetative propagules given in column II.

	Column I		**Column II**
A.	*Bryophyllum*	1.	Offset
B.	*Agave*	2.	Eyes
C.	Potato	3.	Leaf buds
D.	Water hyacinth	4.	Bulbils

Ans. *The correct matching is as follows*

	Column I (Plant Angiosperms)	**Column II** (Vegetative Propagules)
A.	*Bryophyllum*	Leaf buds
B.	*Agave*	Bulbils
C.	Potato	Eyes
D.	Water hyacinth	Offset

In plants, the units of vegetative propagation such as runner, rhizome, sucker, tuber, offset, bulb are all capable of giving rise to new offsprings. These structures are called vegetative propagules.

Q. 15 What do the following parts of a flower develop into after fertilisation?

(a) Ovary ..... (b) Ovules .....

Ans. (a) Ovary ..... fruit (b) Ovules ..... seed

After fertilisation, the zygote develops into the embryo and the **ovules** develop into the **seed**. The **ovary** develops into the **fruit** which develops a thick, protective wall called **pericarp**.

Short Answer Type Questions

Q. 1 In haploid organisms that undergo sexual reproduction, name the stage in the life cycle when meiosis occurs. Give reasons for your answer.

Thinking Process

The requirement of meiosis is to reduce the number of chromosomes to half to maintain the ploidy. As the organism is haploid meiosis cannot occur during gametogenesis.

Ans. Meiosis can take place only in a diploid stage (post-zygotic stage) because the zygote is the only diploid cell in the life cycle of such organisms. This meiosis an case of haploid organisms will occur of the fertilisation.

Q. 2 The number of taxa exhibiting asexual reproduction is drastically reduced in higher plants (angiosperms) and higher animals (vertebrates) as compared with lower groups of plants and animals. Analyse the possible reasons for this situation.

Ans. Higher plants (angiosperms) and higher animals (vertebrates) have a more complex structural organisation as compared to the lower groups of plants and animals. They have evolved very efficient mechanism of sexual reproduction. *These groups have resorted to reproduction by the sexual method for the following reasons*

(i) To ensure healthy progeny

(ii) To produce genetically varied offsprings that adapt to changes in environment and surviveal in all climatic conditions.

(iii) It ensures the genetic recombination that results in variation which gives rise to evolution.

Q. 3 Honeybees produce their young ones only by sexual reproduction. Inspite of this, in a colony of bees we find both haploid and diploid individuals. Name the haploid and diploid individuals in the colony and analyse the reasons behind their formation.

Ans. (i) Sterile diploid females as workers

(ii) One fertile diploid female as queen

(iii) Fertile haploid males as drones.

In case of honeybees, both haploid and diploid individuals formad as a result of incomplete (cyclic) parthenogenesis, *i.e.,* both sexual reproduction and parthenogenesis. Fertilised eggs (zygote) give rise to queen and workers (both are females) by the process of sexual reproduction and unfertilised eggs (ova) develop into drones (males) by the process of parthenogenesis.

Q. 4 With which type of reproduction do we associate the reduction division? Analyse the reasons for it.

Ans. Reduction division (meiosis) is associated with sexual reproduction. *The reasons are*

(i) Since, sexual reproduction involves the fusion of two types of gametes male and female), they must have haploid number of chromosomes.

(ii) The cell (meiocyte) which gives rise to gametes often has diploid number of chromosomes and it is only by reducing the number by half that we can get haploid gametes.

(iii) Reduction division also ensures maintenance of constancy of chromosome number from generation to generation.

Q. 5 Is it possible to consider vegetative propagation observed in certain plants like *Bryophyllum,* water hyacinth, ginger, etc., as a type of asexual reproduction? Give two/three reasons.

Ans. The formation of new plants from vegetative units (vegetative propagules) such as buds, tubers, rhizomes. etc., is called vegetative propagation (vegetative reproduction). It can be considered as a type of asexual reproduction as it involves the production of new individuals.

(i) by a single parent

(ii) without the formation and fusion of gametes

(iii) without resulting in any genetic or morphological variations.

Q. 6 'Fertilisation is not an obligatory event for fruit production in certain plants'. Explain the statement.

Ans. Fertilisation is not an obligatory event for fruit production in certain plants. Some fruits are developed from unfertilised ovary called parthenocarpic fruits.

These are seedless fruits, such as pomegranate, grapes, etc. Flowers of these plants are sprayed by a growth hormone that induces fruit development even though fertilisation has not occurred. The ovules of such fruits, however, fail to develop into seeds.

Q. 7 In a developing embryo, analyse the consequences if cell divisions are not followed by cell differentiation.

Thinking Process

The process of development of embryo from the zygote is referred as embryogenesis. During embryogenesis, zygote undergoes cell division (mitosis) and cell differentiation.

Ans. Cell divisions increase the number of cells in the developing embryo, while cell differentiation helps group of cells to undergo certain modifications to form specialised tissues and organs to form an organism.

At many stages of embryogenesis, if cell differentiation does not occur, the embryo cannot develop into a new organism. It will only remain as a mass of cells.

Q. 8 List the changes observed in an angiosperm flower subsequent to pollination and fertilisation.

Thinking Process

The changes that are subsequent to pollination and fertilisation can be categorised under post-fertilisation changes (events).

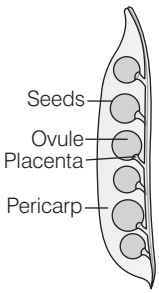
Ans. *In an angiosperm flower, the post-fertilisation changes occur as follows*

Sepal	Fall off
Petal	Fall off
Stamen	Fall off
Zygote	Embryo
Primary endosperm nucleus	Endosperm (3n)
Synergid	Disintegrate
Antipodals	Disintegrate
Ovary	Fruit
Ovule	Seed
Ovary wall	Pericarp (epicarp+mesocarp + endocarp)
Integument	Seed coat (testa+tegmen)
Funicle of the ovule	Stalk of the seed
Micropyle	Seed pore

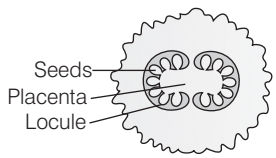
Q. 9 Suggest a possible explanation why the seeds in a pea pod are arranged in a row, whereas those in tomato are scattered in the juicy pulp.

Ans. In pea, fruit is legume. The pea pod is developed from monocarpellary, unilocular and half superior ovary. At maturity, the fruit splits along the dorsal and ventral sutures and discharge its seeds.

In gynoecium with single carpel, ovules are always attached to the ventral suture. This results in the fruit with marginal placentation. Thus, the seeds are arranged in a row in legume (pea) pod.



Marginal placentation in pea



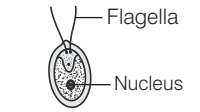
Axial placentation in tomato

In tomato, the fruit is berry. It is fleshy fruit develop from superior or inferior ovary. In this, the margins of the carpels grow inward to the centre of the ovary dividing the central chamber into compartments called locules.

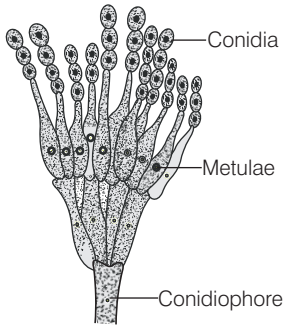
So that, the ovules are arranged radially on the axis, attached by placenta that is called axial placentation. That's the reason the seeds are embedded in the juicy pulp.

Q. 10 Draw the sketches of a zoospore and a conidium. Mention two dissimilarities between them and atleast one feature common to both structures.

Ans. The feature common to zoospores and conidia is that both of these are the asexual reproductive structures, which facilitate the process of reproduction in asexually reproducing organisms.



(a) **Zoospore of *Chlamydomonas***



(b) **Conidium of *Penicillium***

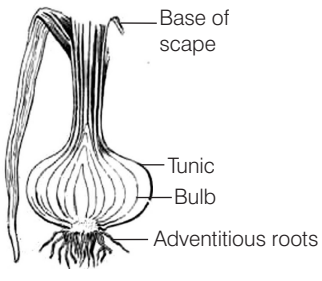
The two dissimilarities between these (zoospore and conidium) are as follows

Zoospore (Found usually in Algae)	**Conidium** (Found usually in Fungi)
Flagellated	Non-flagellated
Formed inside a sporangium (endogenously)	Formed at the tip of conidiophores (exogenously)

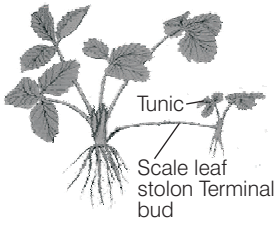
Q. 11 Justify the statement 'vegetative reproduction is also a type of asexual reproduction'.

Ans. In flowering plants, the units of vegetative reproduction such as runners, stolons, suckers, offsets, rhizome, corm, tuber, etc., are capable of giving rise to new offsprings. These structures are called vegetative propagules.

In all these plants the formation of these structures does not involve two parents, the process involved is asexual. So, it can be said that vegetative reproduction is also a type of asexual reproduction.



Bulb of onion



Stolen of strawberry

Long Answer Type Questions

Q. 1 Enumerate the differences between asexual and sexual reproduction. Describe the types of asexual reproduction exhibited by unicellular organisms.

Ans. *The differences between asexual and sexual reproduction are mentioned below*

Asexual Reproduction	Sexual Reproduction
Uniparental	Biparental
Somatic cells are involved.	Germ cells are involved.
It involves the production of asexual spores	It involves the formation and fusion of gametes.
Offsprings are genetically similar to parents.	Offsprings are genetically dissimilar to parents.
The rate of reproduction is faster.	The rate of reproduction is slower.

Asexual reproduction occurs usually in unicellular organisms, such as monerans and protists and in plants and certain animals.

It takes place in the following ways

(i) **Binary Fission** In this type of asexual reproduction, the parent organism divides into two halves, each half forming an independent daughter organism.

e.g., Amoeba, Euglena, Paramecium.

(ii) **Budding** In this type of asexual reproduction, a daughter individual is formed from a small projection, the bud, arising from the parent body.

*e.g.,*yeast, *Hydra*.

(iii) **Fragmentation** In this type of asexual reproduction, the parent body breaks into two or more fragment. Each body fragment develops into an organism.

e.g., sponges, *Selaginella*.

(iv) **Gemmule** In this type of asexual reproduction, internal buds, called gemmules are involved. Gemmules are asexually reproduced mass of cells, that is capable of developing into a new organism.

e.g., sponges.

(v) **Sporulation** In this type of asexual reproduction, dispersive structures called spores are released from the parent body that germinate under favourable conditions form new individuals.

(a) Motile spores are called **zoospores** and are found in aquatic animals. *e.g., Albugo, Chlamydomonas.*

(b) Non-motile spores are named as **sporangiospores** (*e.g., Rhizopus, Mucor*) and **conidia** *e.g., Penicillium*.

Q. 2 Do all the gametes formed from a parent organism have the same genetic composition (identical DNA copies of the parental genome)? Analyse the situation with the background of gametogenesis and provide or give suitable explanation.

Ans. *No*, all the gametes formed from a parent organism do not have the same genetic composition.

It can be better understand with the help of the explanation given below

Sexual reproduction in organisms generally involves the fusion of gametes from two different individuals. These gametes form by the process of gametogenesis. In the heterogametic species, gametes are of two types namely male and female. Gametes are haploid though the parent body from which they arise may be either haploid or diploid.

(a) A haploid parent like Monera, fungi, algae and bryophytes produce gametes by mitotic division. The number of chromosomes, *i.e.,* the genetic composition remain same after such type of division.

(b) The diploid parent like pteridophytes, gymnosperms, angiosperms and most of the animals including human beings produces gametes by meiosis. In such organisms (diploid), specialised cells called meiocytes (gamete mother cell) undergo meiosis.

At the end of meiosis only one set of chromosomes gets incorporated into each gamete. It means the gametes formed contain a haploid number of chromosomes in contrast to the number of chromosomes in mother cells.

Q. 3 Although sexual reproduction is a long drawn, energy-intensive complex form of reproduction, many groups of organisms in kingdom–Animalia and Plantae prefer this mode of reproduction. Give atleast three reasons for this.

Ans. *Follwing are the three reasons for the mode of sexual reproduction in higher group of organisms*

(i) The sexual mode of reproduction ensures creation of new variants.

(ii) Genetically varied offsprings are produced that adapt to changes in environment and survive in all climatic conditions.

(iii) Sexual reproduction ensures the genetic recombination that results in variation which gives rise to evolution.

Q. 4 Differentiate between (a) oestrus and menstrual cycles; (b) ovipary and vivipary. Give an example for each type.

Ans. *The differences between oestrus and menstrual cycle are as follows*

(a)

Oestrus cycle	Menstrual cycle
✦ The cyclic changes in the activities of ovaries and accessory ducts as well as hormones during the reproductive phase of non-primate mammals is called oestrus cycle.	✦ The cyclic changes in the activities of ovaries and accessory ducts as well as hormones during the reproductive phase of primate mammals is called menstrual cycle.
✦ Females show strong irresistible sexual urge.	✦ Females do not show irresistible sexual urge.
✦ There is estrus/heat production at the time of ovulation and copulation occurs only at that period.	✦ There is no heat period and copulation occurs during any time of the cycle.
✦ The shedding of endometrium and bleeding do not occur. *e.g.,* cows, sheep, rats, deers, dogs and tigers etc.	✦ The shedding of endometrium and bleeding occurs. *e.g.*, monkeys, apes and humans.

(b) *The differences between ovipary and vivipary are as follows*

Ovipary	Vivipary
✦ In ovipary, animals lay eggs.	✦ In vivipary, animals give birth to young ones.
✦ The eggs are covered by hard calcareous shell.	✦ Ovum are not covered by calcareous shell.
✦ The development of zygote takes place outside the female's body.	✦ The development of zygote takes place inside the female's body.
✦ Females lay eggs in a safe place in the environment, but the chances of survival are less	✦ Females deliver young ones and the chances of survival are more.
e.g., all birds, most of reptiles are egg laying mammals.	*e.g.,* mammals except monotremes egg laying mammals.

Q. 5 Rose plants produce large, attractive bisexual flowers, but they seldom produce fruits. On the other hand a tomato plant produces plenty of fruits though they have small flowers. Analyse the reasons for failure of fruit formation in rose.

Thinking Process

Both these plants rose and tomato are selected by human beings for different characteristics, the rose for its flower and tomato for its fruit. Roses, being vegetatively propagated do not need to produce seeds.

Ans. Rose plants produce large, attractive bisexual flowers, but they seldom produce fruits. *The reasons for failure of fruit formation in rose are as follows*

(i) Rose plants may not produce viable pollens, hence, no fertilisation can take place.

(ii) Rose plants may not have functional eggs.

(iii) Rose plants may have defective and non-functional ovule ,which is the female gametophyte generator.

(iv) There may be self-incompatibility.

(v) There may be internal barriers for pollen tube growth or fertilisation.

(vi) As rose plants are hybrids and reproduce vegetatively, there are chances for them to be sterile.