SECTION-A (Multiple choice questions)

Q. 1-Answer

(i) **a** (ii) **b** **(iii) b** **(iv) a** **(v) a** (vi) **c** **(vii) a**

(viii)a **(ix)c** **(x)** c

SECTION –B (Descriptive type questions)

Q. 2-Answer

Selection coefficient: The coefficient of selection (denoted as 's') is usually taken to be a measure of the extent to which natural selection is acting to reduce the relative contribution of a given genotype to the next generation. It is used by researchers to calculate the rate at which gene frequencies change from generation to generation within a population.

The selection coefficient (s) is a number between zero and one. If s = 1, selection against the genotype is total, and it makes no contribution to the next generation. If s = 0, the genotype is not selected against at all.

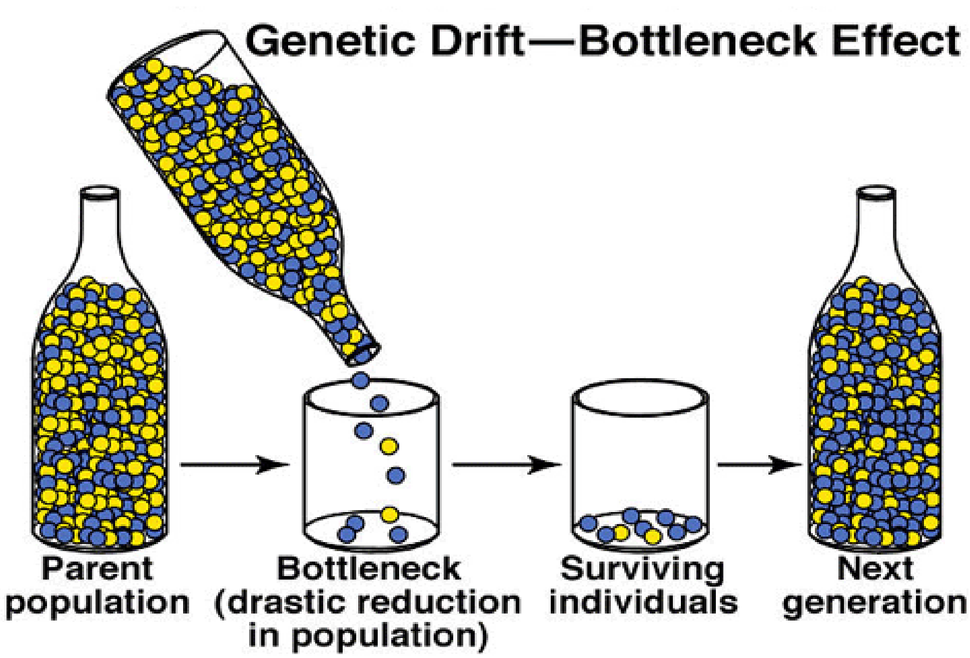
Example: Suppose there are two alleles (dominant 'A' and recessive 'B') for a particular gene in a population. If gene frequency of allele A is p and of B is q, according to Hardy Weinberg's law of equilibrium, in panmictic population p + q = 1 and the three genotypes produced as a result of combinations of these will be: AA = p^2, AB = 2AB and BB = B^2

i.e. AA + 2(AB) + $B^2 = p^2 + 2pq + q^2$

If the population is at equilibrium, these frequencies will remain unaltered. But if population exhibits differential reproduction due to selection operating against the recessive allele, the effect of selection is represented by selection coefficient (s) which represents the force of natural selection operating against the recessive allele. It means where the genotype AA and AB produced cent percent offspring, BB produce 1 – s. It means AA = 1, BB = 1 - s. The genetic contribution from them will be: AA = p^2 x 1, AB = 2pq x 1 and BB = q^2 (1-s). Since the gametic contribution is equal to the product of the frequency of genes, the genotype frequencies after selection will be p^2, 2pq and $(1-s)q^2$.

Bottle neck phenomenon:

A population may be formed of thousands of individuals but not in the next season or next year only a relatively few individual survive. The few individuals form the pregenerators for the future generation of the population which may multiply sporadically in the next generation and may be decline after one or two generations. This yearly or seasonal phenomenon of cyclic fluctuation in population density leading to periodic squeezing of some of the genes in a gene pool in random fashion is called bottle neck phenomenon, the term used by Stebbins. This is an example of genetic drift.



Q. 3-Answer

Evolutionary forces are the factors responsible for changing the gene frequencies or genotype frequencies (gene pool) in a population and are thus capable of inducing speciation, i.e. formation of new species. These forces mainly include mutation, natural selection, genetic drift and migration (gene flow).

Significance of natural selection in organic evolution:

Natural selection is the differential reproduction of genotypes in a population. It brings about differential contribution of offspring to the next generation. It means individuals that are more adapted to the environment, reproduce at a higher rate and produce more offspring than those which are less adapted. These contribute proportionately greater percentage of genes to the gene pool of subsequent generations. Thus, natural selection act as a guiding force of evolution and it was first time recognized by Charles Darwin.

Based upon different organism-environment relationship, following different kinds of natural selection have been organized:

1. Stabilizing selection

2. Directional selection

3. Disruptive selection

4. Cyclic selection

1. Stabilizing selection: Operates in constant environment and prefer average characters and eliminate extreme characters. Example: Sparrows, Red Checkered Moth, etc.

2. Directional selection: It operates when environment is changing in one direction. It favors non-average or specialized phenotypes and eliminates the normal or average individuals. Example: Industrial melanism, drug resistance etc.

3. Disruptive selection: It acts to break up a previously homogenous population into several different adaptive forms. It indicated that extreme values have the highest fitness and the intermediate or mean values are relatively disadvantageous. It operates when a population previously adapted to a non-homogenous environment is subjected to divergent selection pressures in different parts of its distributional areas. Example: Sunflower population and Mimetic butterflies.

4. Cyclic selection: It operates when environment is not stable between generation or between seasons, the optimum phenotype and also the optimum genotype may show fluctuation because of selection operating in one direction in one generation or season, and in opposite direction for the next. This type of selection is called cyclic selection. It helps in maintaining genetic differences in a population and fixes all the allels of the gene pool.

Significance of genetic drift in organic evolution:

Genetic drift, along with natural selection, mutation, and migration, is one of the basic mechanisms of evolution.

Allele frequencies in small populations do not generally reflect those of larger populations since too small of a set of individuals cannot represent all of the alleles for the entire population.

Genetic drift occurs when the population size is limited and therefore by chance, certain alleles increase or decrease in frequency. This can result in a shift away from Hardy-Weinberg equilibrium (HWE). Unlike natural selection, genetic drift is random and rarely produces adaptations to the environment.

Q. 4-Answer

Polymorphism in biology occurs when two or more clearly different phenotypes exist in the same population of a species — in other words, the occurrence of more than one *form* or *morph*. In order to be classified as such, morphs must occupy the same habitat at the same time and belong to a panmictic population (one with random mating). In evolutionary point of view, polymorphism comprises natural variations in a gene, DNA sequence, or chromosome that have no adverse effects on the individual and occur with fairly high frequency in the general population. **Adaptive genetic polymorphism** emphasizes the adaptive evolution and maintenance of genetic diversity in fluctuating environment. Both evolution and ecology have long been concerned with the impact of variable environmental conditions on observed levels of genetic diversity within and between species. Adaptive genetic polymorphism explains the evolution of a trait under selection that fluctuates in space and time, and derives an analytical condition for when these fluctuations promote genetic diversification.

Chromosomal polymorphism

In genetics, chromosomal polymorphism is a condition where one species contains members with varying chromosome counts or shapes. Polymorphism is a general concept in biology where more than one version of a trait is present in a population.

In some cases of differing counts, the difference in chromosome counts is the result of a single chromosome undergoing fission, where it splits into two smaller chromosomes, or two undergoing fusion, where two chromosomes join to form one. This condition has been detected in many species. *Trichomycterus davisi*, for example, is an extreme case where the polymorphism was present within a single chimeric individual. It has also been studied in alfalfa, shrews, Brazilian rodents, and an enormous variety of other animals and plants. In one instance it has been found in a human. Another process resulting in differing chromosomal counts is polyploidy. This results in cells which contain multiple copies of complete chromosome sets. Possessing chromosomes of varying shapes is generally the result of a chromosomal translocation or chromosomal inversion. In a translocation, genetic material is transferred from one chromosome to another, either symmetrically or asymmetrically (a Robertsonian translocation). In an inversion, a segment of a chromosome is flipped end-for-end. Polymorphism results from evolutionary processes, as does any aspect of a species. It is heritable and is modified by natural selection.

Implications for speciation

All forms of chromosomal polymorphism can be viewed as a step towards **speciation.** Polymorphisms will generally result in a level of reduced fertility, because some gametes from one parent cannot successfully combine with all gametes of the other parent. However, when both parents contain matching chromosomal patterns, this obstacle does not occur. Further mutations in one group will not flow as rapidly into the other group as they do within the group in which it originally occurred.

Further mutations can also cause absolute infertility. If an interbreeding population contains one group in which (for example) chromosomes A and B have fused, and another population in which chromosomes B and C have fused, both populations will be able to interbreed with the parent population. However, the two subpopulations will not be able to breed successfully with each other if the doubling of chromosome B is fatal. Similar difficulties will occur for incompatible translocations of material.

Q. 5-Answer

Phylogeny is derived from a combination of Greek words. "Phylon" means stem and "genesis" means origin. In **molecular phylogeny**, the relationships among organisms or genes are studied by comparing homologues of DNA or protein sequences. Dissimilarities among the sequences indicate genetic divergence as a result of molecular evolution during the course of time.

Molecular phylogenetic methods are based on assumptions about the processes of molecular evolution working on DNA or protein sequences. In *in silico* experiments (i.e. using computers), the evolution of a sequence into several lineages can be simulated and the resulting data set can be subjected to phylogenetic analyses. Under these conditions, the true phylogenetic tree is known and can be used to test the accuracy, consistency and robustness of phylogenetic methods and evolutionary models. Example: Evolution of hemoglobin, cytochrome c etc.

In **balanced polymorphism**, individuals with two or more forms coexist in the same population of a species in stable environment and show almost constant ratio. It means the genotype frequencies of various forms occur at equilibrium. The superior fitness of some heterozygotes relative to homozygotes is called heterozyogote superiority or also described as heterosis. Examples: Sickle cell anaemia: In malaria infested areas, sickle cell heterozygote

(Hb^A/Hb^S) or the carriers are resistant to malarial infection and are less infected with parasite than the homozygous dominant nonsicklers or normal haemoglobin (Hb^A/Hb^A) and sickle cell anaemia (Hb^S Hb^S). Thus the heterozygotes have better chances of survival than the normal homozygote. This advantage of heterozygotes results in stable polymorphism for gene Hbs.

Other examples of balanced polymorphism are ABO blood groups and Drosophila polymorphasim.

The stabilizing selection or normal selection is also called centripetal selection. It acts in the absence of large scale environmental changes for a long period. It favors the average or normal phenotype, just like to balanced polymorphism, and eliminates the extreme variants that fall towards both ends of the bell-shaped curve of variability for the distribution of measurements of phenotypic traits. The elimination may be either physical or by genetic death.

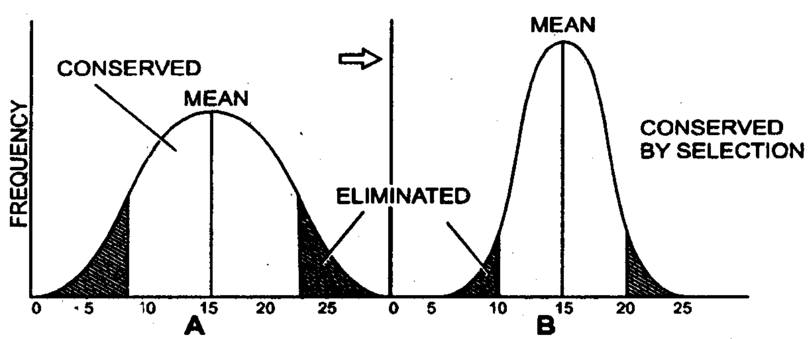


Fig. 4. The bell-shaped curve for the distribution of measurements of the phenotypic traits produced by stabilising selection.

Answer No. 6

Malaria

French army doctor working at the military hospital in Algeria named **Charles Louis Alphonse Laveran** observed malarial parasites for the first time inside the red blood cells of people suffering from malaria. For this and later discoveries, he was awarded the 1907 Nobel Prize for Physiology or Medicine. The protozoan was named *Plasmodium* by the Italian scientists **Ettore Marchiafava** and **Angelo Celli**. A year later, **Carlos Finlay**, a Cuban doctor treating patients with yellow fever in Havana, first suggested that mosquitoes were transmitting disease to humans. However, it was **Sir Ronald Ross** working in India who finally proved in **1898** that malaria was transmitted by mosquitoes to birds. He isolated malarial parasites from the salivary glands of mosquitoes that had fed on infected birds. For this work Ross received the **1902** Nobel Prize in Medicine. The findings of Finlay and Ross were confirmed by a medical board headed by Walter Reed in 1900.
Malaria is a disease of the blood that is caused by the Plasmodium parasite, which is transmitted from person to person by a particular type of mosquito. The female Anopheles mosquito is the only mosquito that transmits malaria.

Anopheles mosquito primarily bites between the hours of 9pm and 5am, which is why sleeping under a mosquito net at night is such an important method of prevention. There are more than 100 species of malaria parasite. The most deadly and most common in Africa is known as *Plasmodium falciparum* and in India is *Plasmodium vivex.*

Once the parasite enters the human body, it lodges itself in the liver where it multiplies approximately 10,000 times. Two weeks after entering the body, the parasite bursts into the blood stream where it begins infecting red blood cells. The first effective treatment for malaria was the bark of **cinchona tree**, which contains **quinine**.

AIDS

AIDS stands for Acquired Immunodeficiency Syndrome. It is the most advanced stage of infection with the Human Immunodeficiency Virus (HIV) which kills or damages cells of the body's immune system. HIV most often spreads through unprotected sex with an infected person, by sharing drug needles or through contact with the blood of an infected person. Women can give it to their babies during pregnancy or childbirth.

HIV is a virus spread through body fluids that affects specific cells of the immune system, called CD4 cells, or T cells. Over time, HIV can destroy so many of these cells that the body can't fight off infections and disease. When this happens, HIV infection leads to AIDS.

The first signs of HIV infection may appear as swollen glands and flu-like symptoms which may come and go a month or two after infection. Severe symptoms may not appear until months or years later. The CD4 count indicates how far the HIV disease has advanced. CD4 counts in adults range from 500 to 1,500 cells per cubic millimeter of blood. In general, the CD4 count goes down as HIV disease progresses, to below 200, regardless of whether the persons are sick or not.

Once HIV enters the human body, it attaches itself to a White Blood Cell (WBC) called CD4, also called T4 cell, which are the main disease fighters of the body. Whenever there is an infection, CD4 cells lead the infection-fighting army of the body to protect it from falling sick. Hence damage of these cells can affect a person's disease-fighting capability and general health. After making a foothold on the CD4 cell, the virus injects its RNA into the cell. The RNA then produces its DNA by using enzyme reverse transcriptase. The viral DNA then gets attached to the DNA of the host cell and thus becomes part of the cell's genetic material. It is a virtual takeover of the cell. Using the cell's division mechanism, the virus now replicates and churns out hundreds of thousands of its own copies. These cells then enter the blood stream, get attached to other CD4 cells and continue to replicate. As a result the number of virus in the blood rises and CD4 cell count declines.

Tuberculosis

TB is a disease caused by a bacterium called *Mycobacterium tuberculosis.* The bacteria usually attack the lungs, but TB bacteria can attack any part of the body such as the kidney, spine, and brain. If not treated properly, TB disease can be fatal.

TB is spread through the air from one person to another. The TB bacteria are put into the air when a person with TB disease of the lungs or throat coughs, sneezes, speaks, or sings. People nearby may breathe in these bacteria and become infected.

Latent TB Infection and TB Disease: Not everyone infected with TB bacteria becomes sick. As a result, two TB-related conditions exist:latent TB infection and TB disease.

Latent TB Infection: TB bacteria can live in the body without making you sick. This is called latent TB infection. In most people who breathe in TB bacteria and become infected, the body is able to fight the bacteria to stop them from growing. People with latent TB infection do not feel sick and do not have anysymptoms. People with latent TB infection are not infectious and cannot spread TB bacteria to others. However, if TB bacteria become active in the body and multiply, the person will go from having latent TB infection to being sick with TB disease.

TB Disease

TB bacteria become active if the immune system can't stop them from growing. When TB bacteria are active (multiplying in your body), this is called TB disease. People with TB disease are sick. They may also be able to spread the bacteria to people they spend time with every day.

Many people who have latent TB infection never develop TB disease. Some people develop TB disease soon after becoming infected (within weeks) before their immune system can fight the TB bacteria. Other people may get sick years later when their immune system becomes weak for another reason.

TB disease can be treated by taking several drugs, usually for 6 to 9 months. It is very important to finish the medicine, and take the drugs exactly as prescribed. If you stop taking the drugs too soon, you can become sick again. If you do not take the drugs correctly, the germs that are still alive may become resistant to those drugs. TB that is resistant to drugs is harder and more expensive to treat.

Answer No. 7

Lac production:

Members of two families of Hemiptera, namely, Lacciferidae and Tachardinidae secrete lac over their bodies for protection. Lac Insect belongs *Laccifer* of superfamily Coccoidea of order Hemiptera. In all 22 species have been recorded under the genus *Laccifer* in Indian subcontinent.

India is still being regarded as the principal lac producing country of the world. Burma went into lac trading since sixteenth century. Lac culture in China probably dates back to 4000 years and they use lac for dyeing silk and leather goods. India produces about 65% of the world's total output. Bihar and Jharkhand account for 40% of India's total production of lac.

Plants such as, *Zizyphus mauritiana, Z. jujuba, Butea monosperma, Schleichera oleosa, Acacia arabica, A catechu, Cajanus cajan, Ficus benghalensis, F. cunia,*and *F.* religiosa are common hosts of the lac insect *Laccifer (=Tachardia) lacca.*

Lac life cycle: *Laccifer lacca, (=Tachardia lacca)* is the commercially cultured lac insect. It is mainly cultured in India and Bangladesh on the host plants such as ber,*Zizyphus mauritiana*, palas, *Butea monosperma* and kusum, *Schleichera oleosa.*

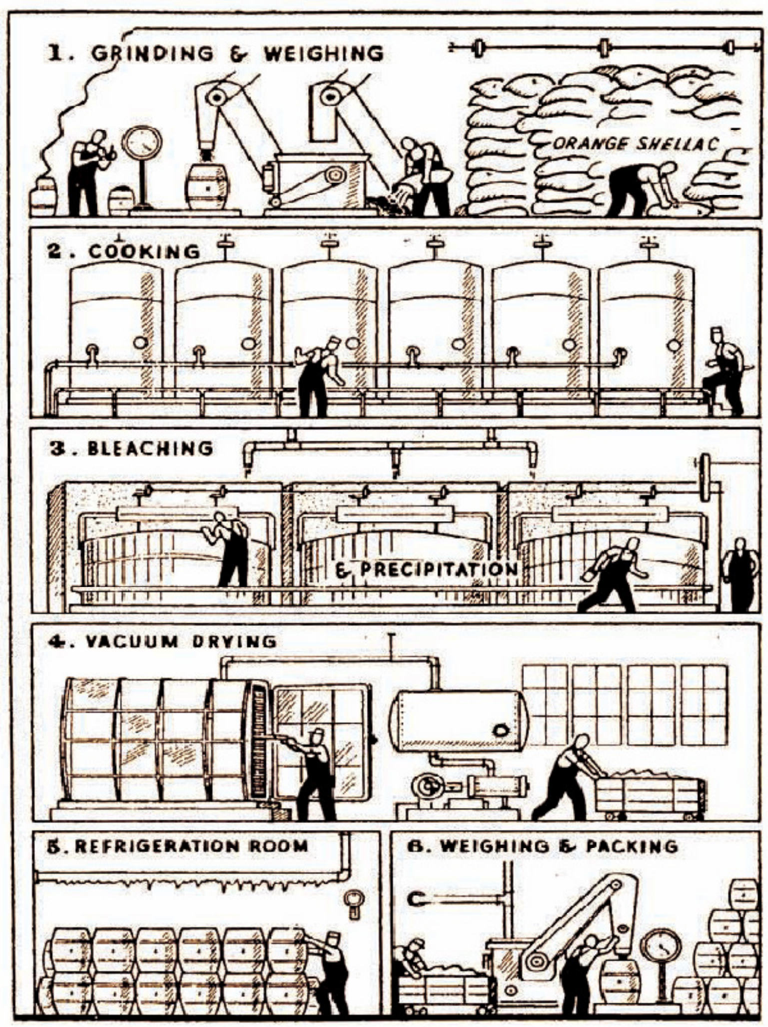
Female insect is viviparous, producing about 1000 nymphs, deep red in colour with black eyes. The larvae settle down on a suitable place of the host plant gregariously. A day or two after settlement, the larvae start secreting lac all around the body except on the rostrum, spiracles and on the tip of abdomen. Thus it gets encased in a cell of lac which gradually increases in size along with the increase in size of the insect. The insect moults twice before reaching maturity. The male larvae produce elongated lac cells while the females produce oval cells

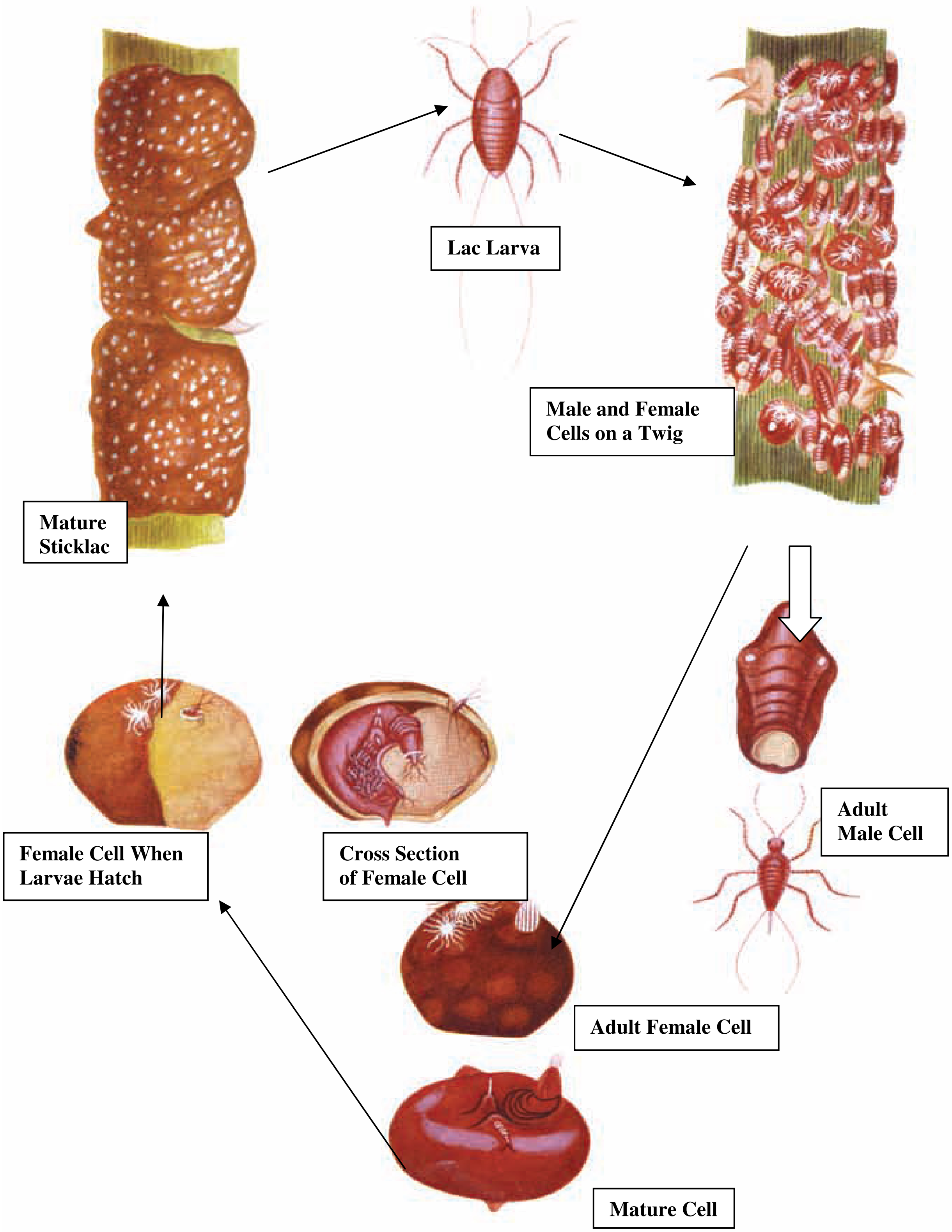
After the first moult larvae lose their legs, antennae and eyes and become bag-like. After the 3rd moult, the larvae pass on to a pseudo-pupal stage. Males emerge and copulate with the females and die. The female larvae never regain appendages and continue to remain under the lac cell, become adults and reproduce. As the lac insects remain close together, lac secretion from adjacent cells coalesces with each other and forms a continuous encrustation on the tree branch.

Processing of lac

Lac encrustations are removed from the twigs of host plants by scraping. The raw lac thus obtained is known as scraped lac or stick lac. Stick lac is crushed into small grains, sieved, washed with mild alkaline water and dried. This semi-refined product, called seed lac or grain lac or Chowrie, which is further refined by a system of hot melting, filtration and stretching into thin sheets which are subsequently broken into brittle flakes called shellac. Alternatively the purified lac resin can be in the form of circular discs called button lac. If a solvent process is used to purify the raw lac, de-waxed, decolorized lac can be obtained as the end product. The normally amber coloured resin can also be bleached with sodium hypochlorite to obtain bleached lac, which is white in colour. Bleached lac has specialised demand for coating medicinal tablets, confectioneries etc.

Lac production process




Lac Larva
Male and Female Cells on a Twig
Mature Sticklac
Adult Male Cell
Female Cell When Larvae Hatch
Cross Section of Female Cell
Adult Female Cell
Mature Cell

Answer No. 8

Pearl is produced by black lip pearl oyster or pearl oyster, *Pinctada margaritifera (var. cumingii) and P. vulgaris*, which grow to a size of 12-15 cm after 3 years of culture. Pearl oysters occur throughout the Indo-Pacific Region. They have been fished for almost two centuries for the mother-of-pearl industry and fine pearls were occasionally harvested from the sea. To overcome the decimation of wild populations, spat collection tests were undertaken at the beginning of the 20th century but the technique was only developed in the late 1950s. There was a renewal of interest in pearls in the 1960s and the first grafts were carried out by the French Fisheries Service, and the first grafted pearls were harvested in 1965. In the 1970s, through private initiatives, this oyster began being cultured for pearl production and a market was developed for Polynesian black pearls.

Culture techniques

Layer upon layer of nacre, also known as mother-of-pearl, coat the grain of sand until the iridescent gem is formed. Cultured pearls are made in the same way. The only difference is that instead of accidental circumstances, a "pearl farmer" embeds a grain of sand into the mollusk.

Hatchery rearing of spat is not yet fully controlled. Pearl oyster rearing chains are suspended from a long line. Spat for culturing is collected in the natural environment by setting artificial substrates. After 12-24 months without any intervention, the oysters grow to 5-10 cm and are then set on oyster-rearing chains suspended from the subsurface long lines at 6 to 10 m depth. 4,000 to 10,000 oysters are set on each of these 200 m oyster-rearing chains, which are spaced 10 m apart. After 3-12 months, the oysters reach a size of around 10 cm and weigh about

120 g, and at this stage they are ready to be grafted. After grafting, the oysters are again set on long lines until the pearl grows, which is generally around 18 months. The regulations stipulate a maximum density of 2,400 oysters per 200 m oyster-rearing chain. Only 25-30% of these oysters form a marketable pearl, rest are rejected, die or produce poor quality pearls.

The kechi pearl is formed by inserting pieces of the mantle of one mollusc into the gonad of another. The result will be small, less than 7 mm, odd-shaped pearl but no nucleus is required and as many as 20 pearls may be produced. When a nucleus is used, larger than 7 mm pearls are formed, which are called "baroque". Mabe pearls are grown extensively by the American pearl companies because they are relatively easy to implant. A semi-spherical core (plastic in the case of Cross and Peach, and mother-of-pearl in the case of Latendresse type) is inserted under the mantle, which is gradually covered by nacre resulting in a half pearl. Different shapes such as rounds, kechis, baroques and mabes can be produced from the same oyster by inserting nuclei of various shapes.