

Biology	Group-II	PAPER: II
Time: 2.40 Hours	(SUBJECTIVE TYPE)	Marks: 68

SECTION-I

2. Write short answers to any EIGHT (8) questions: (16)

(i) Enumerate four adaptations of xerophytes in terrestrial habitat.

Ans Xerophytes have the adaptations for reduced rate of transpiration. Many xerophytes possess small, thick leaves to limit water loss by reducing surface area proportional to the volume. Their cuticle is thick, waxy and leathery. Stomata are on lower surface of leaves and located in depression. Some as cacti, during the driest season, shed their leaves to restrict transpiration completely, thus stems are the photosynthetic organs.

(ii) Differentiate between osmoregulation and thermoregulation.

Ans The mechanism of regulation, generally between organism and its environment, of solute and the gain and loss of water is osmoregulation. On the other hand, the mechanism which eliminates nitrogenous waste is referred as excretion, whereas, maintenance of internal temperature within a tolerable range is designated as thermoregulation.

(iii) What are pyrogens? Give their function.

Ans Pyrogens are the chemicals produced by pathogens and blood cells. It happens in bacterial and viral infections in which leukocytes increase in number.

(iv) Differentiate between epinasty and hyponasty.

Ans **Epinasty:**

It is shown by leaves, petals, etc. Upper surface of leaf in bud condition shows more growth as compared with the lower surface. This leads to opening of buds.

Hyponasty:

If growth in the lower surface of the leaf in bud condition is more than that of the upper surface then the bud will remain closed.

(v) What is foramen triosseum? Give its function.

Ans In birds, an opening formed between the scapula, coracoid and clavicle bone through which tendon of supracoracoid muscle passes and is attached to the upper surface of humerus.

(vi) What is rigor mortis? Give its cause.

Ans A condition in which body becomes stiff is called rigor mortis. After death, the amount of ATP in the body falls. Under these circumstances, the bridges cannot be broken and so they remain firmly bound.

(vii) Define parthenocarpy. Give its example.

Ans Parthenocarpy is the production of a fruit without the setting of seeds. The process is an irrelevance in the life history of a plant. It does not benefit the plant in any way. Parthenocarpy is most often seen in plants with numerous ovules in the fruit, e.g., fig and melon.

(viii) What is corpus luteum? Give its function.

Ans The follicle cells, after release of the egg are modified to form a special structure called corpus luteum. This structure releases progesterone hormone.

In case of no fertilization, corpus luteum starts degenerating which diminishes progesterone secretion and its supporting effect on endometrium is reduced which suffers of break down. This causes the discharge of blood.

(ix) Define profundal zone. Name living organisms found in it.

Ans In profundal zone, light is insufficient to support photosynthesis. The organisms of this zone are mainly nourished by detritus that falls from the littoral and limnetic zone and by incoming sediment. Decomposers and detritus feeders, such as, snails and certain insect larvae, bacteria, fungi and fishes, inhabit it.

(x) What is tundra? Where is it found in Pakistan?

Ans The last biome seen before reaching the polar ice-caps is the arctic tundra, a vast treeless region boundary, the Arctic ocean. The location of Tundra Ecosystem in Pakistan is Mountains of Kara-Koram and Hindukush.

(xi) Define eutrophication. Give its impact.

Ans The natural process of excessive enrichment of water with nutrients by which large amount of living organic matter grows in water. The nitrates and phosphates are added in the water where they decompose by the activity of bacteria.

(xii) Differentiate between afforestation and reforestation.

Ans Afforestation is establishment of new forests where no forests existed previously. While reforestation is the replantation of trees. It is important for many conifer species which require bare soil to establish.

3. Write short answers to any EIGHT (8) questions: (16)

(i) What is epilepsy?

Ans Epilepsy is one of the convulsive disorder of nerves which is characterized by abrupt transient symptoms of motor, psychic or autonomic nature, usually associated with changes in consciousness. The onset of epilepsy is usually before age 30.

(ii) Give commercial application of Gibberellins.

Ans Some of their commercial applications are as under:

1. GA promote fruit setting e.g., in tangerines and pears and are used for growing seedless grapes (parthenocarpy) and also increase the berry size.
2. GA_3 is used in the brewing industry to stimulate α -amylase production in barley and this promotes malting.
3. To delay ripening and improve storage life of bananas and grape fruits.

(iii) Define imprinting.

Ans Brief exposure of an organism to the stimulus with long lasting effect is called imprinting.

(iv) State Mendel's Law of Independent Assortment.

Ans Mendel formulated law of independent assortment: "When two contrasting pairs of traits are followed in the same cross, their alleles assort independently into gametes."

(v) What is test cross? Give its importance.

Ans Mendel devised a cross called test cross which is used to test the genotype of an individual showing a dominant phenotype. It is a mating in which an individual showing a

dominant phenotype is crossed with an individual showing its recessive phenotype. This cross finds out the homozygous or heterozygous nature of the genotype.

(vi) Differentiate between autosomes and sex chromosomes.

Ans Autosomes are the somatic chromosomes which control the body characters, whereas sex chromosomes control the sex linked characteristics of the organisms. The normal human has 23 different types of chromosomes and 2 copies of each parent.

(vii) What is genomic library?

Ans A genomic library is a collection of bacterial or bacteriophage clones, each clone containing a particular segment of DNA from the source cell. For making a genomic library, an organism's DNA is simply sliced up into pieces, and pieces are put into vectors (*i.e.*, plasmids or viruses) that are taken up by host bacteria. The entire collection of bacterial or bacteriophage clones that result contains all the genes of that organism.

(viii) Define transgenic organisms.

Ans Organisms that have a foreign gene inserted into them are called transgenic organisms. Transgenic bacteria have been produced to promote health of plants. Techniques have been developed to introduce foreign genes into immature plant embryos. Genes are inserted into the eggs of animals by using techniques.

(ix) Give two advantages of PCR.

Ans Advantages of PCR:

1. It can withstand high temperature, which is used to separate double stranded DNA, therefore, replication need not be interrupted by the need to add more enzyme.
2. PCR is done these days in an automatic PCR machine or thermocycler, which is a routine piece of equipment in any laboratory.

(x) Differentiate between habitat and niche.

Ans The area or type of environment in which, a particular kind of animal or plant usually lives is called habitat. While the resources that, an organism exploits to meet its energy, nutrient and survival demands is known as niche.

(xi) What is mutualism? Give example.

Ans The relationship between two organisms in which both the organisms benefit from each other. Lichens are an example of mutualism between a fungus and an alga.

(xii) Define synecology and autecology.

Ans

Difference

Autecology	Synecology
The study of relationship of individual species and environment is called as autecology.	The study of relationship between communities and environment is called as synecology.

4. Write short answers to any SIX (6) questions: (12)

(i) Differentiate between rough and smooth type of bacteria.

Ans

Rough and Smooth bacteria:

The bacteria which are virulent can cause disease and form smooth colonies on a culture disk called smooth bacteria. The bacteria which are non virulent, can not cause disease and form rough colonies on a culture dish are called rough bacteria.

(ii) How many DNA polymerases are found? Write down their names.

Ans

Three DNA polymerases are found. They are DNA polymerase -I, DNA polymerase II, DNA, polymerase-III.

(iii) What are the contributions of P.A. Levene for determining the structure of DNA?

Ans

He found that DNA contains three main components i.e., phosphate (PO_4) group, five carbon sugar and nitrogen containing bases called purines (adenine, A, and guanine G) and pyrimidines (thymine, T and cytosine, C, RNA contains uracil, U, instead of T).

(iv) Differentiate between apical meristems and lateral meristems.

Ans

Apical Meristem:

The apical meristems are found at the tips of roots and shoot and are primarily concerned with the extension of plant body. These are perpetual growth zones found at the apices of roots and stems. They are responsible for increase in the number of cells at the tips of roots and stem. So, they play important role in primary growth.

Lateral Meristems:

Lateral meristems are cylinders of dividing cells. They are present in dicots and gymnosperms. Vascular and cork cambium are the examples of lateral meristem. They play an important role in the increase in diameter of stem and root, and in secondary

growth are determinate i.e., they grow to certain size and then stop e.g., leaves, flowers and fruits, while others are indeterminate i.e., they grow by meristems that continually replenish themselves, remaining youthful e.g., vegetative root and stem.

(v) What is the difference between epiblast and hypoblast?

Ans During gastrulation, the blastoderm splits into two layers: an upper layer of cells is called epiblast, while the lower layer is called hypoblast.

(vi) Write down the functions of mitotic apparatus.

Ans It is designed to attach and capture chromosomes, aligning them and finally separating them so that equal distribution of chromosomes is ensured.

(vii) What is a Turner's syndrome? Write briefly.

Ans These individuals have one missing x chromosome with only 45 chromosomes (44 autosomes of x). Individuals with this condition often do not survive pregnancy and are aborted. Those who survive have female appearance with short stature, webbed neck, without ovaries and complete absence of germ cells.

(viii) Define endangered species with special reference to Pakistan.

Ans A species which is in imminent danger of extinction throughout its range.

In Pakistan, Indus dolphin, Blackbuck, Common leopard, Great Indian bustard, Houbara bustard, white-headed duck are among the animals near to extinction.

(ix) How molecular biology be used as an evidence of evolution?

Ans Evolutionary relationships among species are reflected in their DNA and proteins in their genes and gene products. If time species have genes and proteins with sequences of monomers that much closely, the sequences must have been copied from a common ancestor.

SECTION-II

NOTE: Attempt any Three (3) questions.

Q.5.(a) Describe thermoregulation in mammals. (4)

Ans Thermoregulation in mammals:

Mammals including human maintain their high body temperature within a narrow range of about 36 – 38°C because

of their endothermic characteristics. The origin of endothermy in birds and mammals have provided the opportunity to keep high metabolic rate and availability of energy round-the-clock.

These regulate the rate of metabolic heat production, balancing it with the rate at which they gain or lose heat from the surroundings.

Shivering thermogenesis:

The rate of heat production is increased by increased muscle contraction by movements or shivering, so called as shivering thermogenesis.

Non-shivering thermogenesis:

The hormones trigger the heat production as do thyroid hormones are termed as non-shivering thermogenesis.

In Cold Temperature:

Mammals have various mechanisms that regulate heat exchange with their environment. Similarly, marine mammals such as whales and seals inhabit much colder water than their body temperature, have a very thick layer of insulating sheet called as *blubber* just under the skin.

In Warm Temperature:

Marine mammals dispose off their excess heat into warm seas by large number of blood vessels in the outer layer of the skin. The sweat gland activity and the evaporating cooling is the one of the major temperature regulating phenomena. Bats etc. use saliva and urine for evaporative cooling.

(b) Explain food web and its trophic levels. (1,3)

Ans Food web network:

Food web is actually "the combination of many food chains". Food webs are not really as simple as described in the following figure because most animals eat more than one type of food at different times as fox does not feed entirely on rabbit but also takes beetles, rats, etc.

All the food chains and food webs begin with a green plant (producer) and may consist of three to five links or trophic levels.

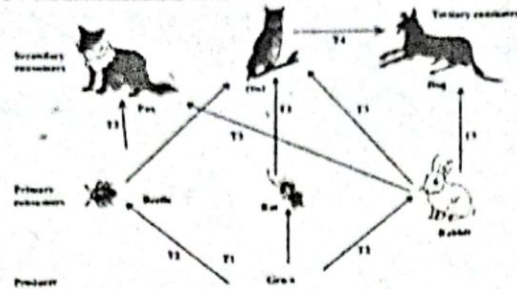


Fig. Food Web and various trophic levels.

In a food web, you will find more complex trophic levels or food links. In the above figure, food chain T_1 is the first trophic producer level includes all green plants, grass, and phytoplankton. T_2 second trophic level - primary consumers. T_3 third trophic level - secondary consumers. T_4 fourth trophic level - tertiary consumers.

The variety of pathways in a food web helps to maintain the stability of the ecosystem. For example, owls prey on rabbits and mice. If a disease reduces the rabbit population, a fewer plants are consumed. The larger plant population produces more fruit and seeds, which, in turn, support a larger mouse population. The increased number of mice becomes the major food source for the owls. The rabbit population gradually increases, and these primary consumers again become a food source for the owls. Thus nature maintains a balance.

Q.6.(a) What are joints? Explain various types of joints. (4)

Ans Joints:

Joints occur where bones meet. They not only hold our skeleton together, but also give it the mobility.

Classification of Joints on the Basis of the Amount of Movement:

Joints are classified on the basis of the amount of movement allowed by them, into three categories:

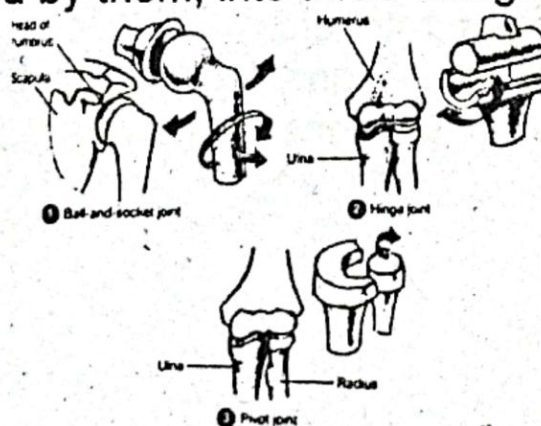


Fig. Three kinds of joints.

- (i) Immovable joints
- (ii) Slightly movable joints
- (iii) Freely movable joints

The freely moveable joints are of two types viz. Hinge joint ball and socket joint.

Classification of joints on the basis of structure:

Joints are also classified on the basis of structure:

1. Fibrous Joints:

These joints are held together by short fibres embedded in connective tissue. Such joints are present in the skull, which fix teeth into jaws.

2. Cartilaginous Joints:

These joints allow little or no movement. Hyaline cartilage forms joint between growing bones. The bones held together by fibrous cartilage are found between vertebrae at the point where coxal bones meet in front of the pelvis.

3. Synovial Joints:

These joints contain a cavity filled with fluid and are adapted to reduce friction between the moving joints. The joint is surrounded by a layer of connective tissue called "fibrous capsule" and their inner layer synovial membrane. Some parts of capsule may be modified to form distinct "Ligament", holding the bones together.

Based on structure and movements allowed, the synovial joints can be classified further into major categories hinge joint and ball and socket joint.

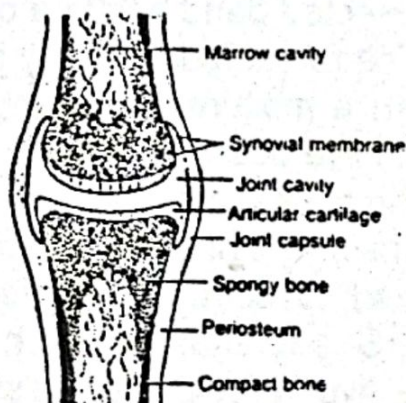


Fig. A typical synovial joint.

i. Hinge Joint:

The joint that allows the movements in two directions is called hinge joint. These are at elbow and knee. At these joints, pairs of muscles are arranged in the same plane as that of

joints. One end of each muscle, the origin is fixed to the immovable bone on one side of joint and the other end of muscles, the insertion is attached to the far side of the joint.

ii. Ball & socket Joint:

These joints allow the movement in several directions. Such joints have at least two pairs of muscles present perpendicular to each other. They provide maximum flexibility. Hip joint and shoulder joint are the examples of ball and socket joints.

(b) Prove that DNA is the hereditary material. (4)

Ans DNA as Hereditary Material:

The first evidence of hereditary nature of DNA was provided by a British microbiologist Frederick Griffith who made some unexpected observations while experimenting with pathogenic bacteria. When he infected mice with a virulent strain of *streptococcus pneumoniae* bacteria (then known as *Pneumococcus*), the mice died of blood poisoning. However, when he infected similar mice with a mutant strain of *S. pneumoniae* that lacked the virulent strains polysaccharide coat, the mice showed no ill-effects. The coat was apparently necessary for virulence. The normal pathogenic form of this bacterium is referred to as the S form because it forms smooth colonies on a culture dish. The mutant forms, which lacks an enzyme needed to manufacture the polysaccharide coat, is called the R form because it forms rough colonies.

To determine whether the polysaccharide coat itself had a toxic effect. Griffith injected dead bacteria of the virulent S strain into the mice; the mice remained perfectly healthy. As a control, he injected mice with a mixture containing dead S bacteria of the virulent strain and live coatless R bacteria, each of which by itself did not harm the mice. Unexpectedly, the mice developed the disease symptoms and many of them died. The blood of the dead mice was found to contain high levels of live, virulent streptococcus type S bacteria, which had surface proteins characteristic of the live (previously R) strain. Somehow, the information specifying the polysaccharide coat had passed from the dead, virulent S bacteria to the live, coatless R bacteria in the mixture, permanently transforming the coatless R bacteria into the virulent S variety. Transformation is the transfer of

genetic material from one cell to another and can alter the genetic make up of the recipient cell.

The agent responsible for transforming *Streptococcus* went undiscovered until 1944. In a classic series of experiments, Oswald Avery along with Colin Macleod and Maclyn McCarty characterized what they referred to as the "Transforming principle".

After the labeled viruses were permitted to infect bacteria, the bacterial cells were agitated violently to remove the protein coats of the infecting viruses from the surfaces of the bacteria. This procedure removed nearly all of the ^{35}S label from the bacteria. However, the ^{32}P label had transferred to the interior of the bacteria and was found in viruses subsequently released from the infected bacteria. Hence, the hereditary information injected into the bacteria that specified the new generation of viruses was DNA and not protein.

Q.7.(a) Explain feed-back mechanism. Give an example. (4)

Ans It is a type of interaction in which a controlling mechanism is itself controlled by the products of reactions it is controlling.

For proper body functions, two opposing systems are needed, if there are accelerators, there must be inhibitors. If one hormone in the body promotes or stimulates a reaction, another hormone would be checking the same. In the body, interaction is mainly maintained due to feedback mechanism. In this way, concentration of secretions is itself controlled because certain information is passed to the source or in other words is fed back so that the output of the secretion is adjusted accordingly, depending on the activity of the body. The interaction between the pituitary and other endocrine glands, over which it exerts control, is an example of feedback mechanism and this mechanism is very common in living systems. Feedback in thyroid gland function is described as under:

1. Low body temperature or stress stimulates neurosecretory cells of the hypothalamus, whose releasing hormones trigger the release of Thyroid-stimulating hormone (TSH) in the anterior pituitary.
2. The TSH then stimulates the thyroid gland to release thyroxine.

3. Thyroxine causes an increase in the metabolic activity of most body cells, generating ATP energy and heat.
4. Both raised the body temperature and higher thyroxine levels in the blood inhibit the releasing-hormone cells and the TSH-producing cells.

(b) Discuss importance of forests.

(4)

Ans Importance of Forests:

Forests are very important component of the human environment. They provide protection to man as well as other organisms. Fruits of forest trees are the source of food for a number of animals. Forests regulate the flow of water in the streams, prevent soil erosion and make the environment very pleasant.

Forests provide us with (1) timber (construction wood for houses) (2) fire wood. (3) medicine (herbel medicine, honey, wax) and many other products.

Regions with high rainfall (average 20 inches) are suitable for tree growth. Trees are called environmental buffers, they intercept heavy rainfall and release the water steadily and slowly to soil beneath and to the streams and rivers that start in or flow through them, the tree roots hold the soil in place. Removal of forests allows soil erosion, silting up of lakes and rivers and dams, heavy floods and the loss forever of thousands of species of animals and plants. The disastrous floods in India and Bangladesh in recent years may be attributed to deforestation.

Forest and Climate:

About half of the rain which falls in tropical forests comes from the transpiration by the trees themselves which also keep the environment cool and humid. When forests are removed, this source of rain is also removed. Cloud cover is reduced and the local climate changes quite dramatically. The temperature range from day to night is more extreme i.e., the difference

between day and night temperatures increases considerably, and the rainfall diminishes.

Forest and Biodiversity:

One of the most characteristic features of tropical forests is the enormous diversity of species they contain. Biodiversity refers to "the total number of different species with in an ecosystem and the resulting complexity of interactions among them."

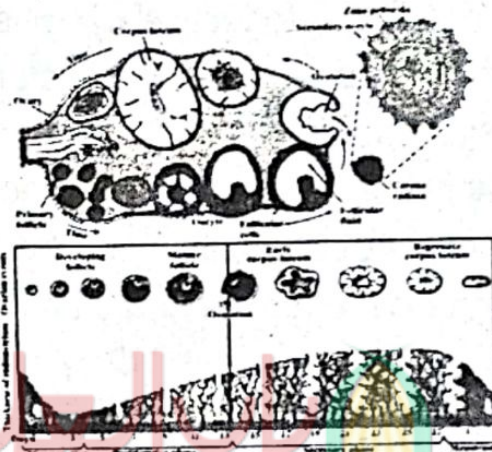
Q.8.(a) Describe the human female reproductive cycle. (4)

Ans Human Female Reproduction Cycle:

In human female, the production of eggs is a cyclic activity. The periodic reproductive cycle is completed in about 28 days. It involves the changes in structure and function of the reproductive system. It is called as 'menstrual cycle'. The menstrual cycle in human has the following steps:

- i. At the onset of puberty, the pituitary gland releases follicle stimulating hormone (FSH). It stimulates the development of many primary follicles. Only one of these follicles continues to grow with its primary oocytes. While the rest breakdown by a degenerative process known as '*follicle atresia*'.
- ii. Under the stimulus of FSH, the ovary produces estrogen hormone. It also stimulates the endometrial (the internal lining of uterus wall) and vascularizes it. It also inhibits the secretion of FSH from pituitary gland.
- iii. Due to the increase of estrogen, the pituitary gland secretes leutinizing hormone.
- iv. After the release of the eggs, the follicle cells are modified to form a special structure called as *corpus luteum*. This yellowish glandular structure secretes hormone called us progesterone. The progesterone develops the endometrium and makes it receptive for the implantation of zygote.

- v. If fertilization does not occur, the corpus luteum starts degenerating. Thus progesterone secretion is reduced and its effect on spongy endometrial cells is reduced. Due to this, the discharge of blood and cell debris occurs. This is called as *menstruation*. Usually, this stage lasts for 3-7 days. The menstrual cycle in human differs in different individuals or even within the same individual at different times of her age. The end of this cycle is called as 'menopause'. After this, the female does not further produce eggs. The menstrual cycle is disturbed due to malnourishment and emotional stress.

















(b) Describe the Law of Independent Assortment with an example. (4)

Ans Mendel's Law of Independent Assortment:

Mendel performed series of breeding experiments on garden pea, in his monastery garden. Pea had many sharply distinct traits. Each trait had two clear-cut alternative forms or varieties.

He first established true-breeding varieties for each trait. A true-breeding variety upon self-fertilization always produced offspring identical to the parents e.g., similarly a true-breeding 'wrinkled' seed plant produced only wrinkled seeds.

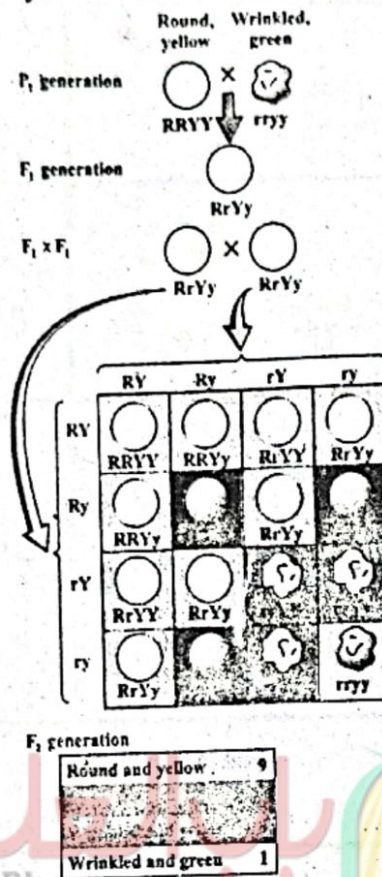
Plant Height	Tall (6-7 feet) 	Short (9-18 inches) 
Flower Colour	Purple 	White 
Flower Position	At leaf junctions (axial) 	At tips of branches (terminal) 
Pod Colour	Green 	Yellow 
Pod Shape	Inflated 	Constricted 
Seed Colour	Yellow 	Green 
Seed Shape	Round 	Wrinkled 

Seven traits of garden pea studied by Mendel.

After establishing 14 pure-breeding organisms of seven characters, Mendel cross-fertilized plants that differed in one character only. The offsprings of such a cross were called *monohybrids*.

Then Mendel crossed pea plants differing in two characteristics. A true breeding round seeded pea variety was cross pollinated with a true breeding wrinkle seeded variety. All the seeds in F₁ generation were yellow and round. The allele for yellow cotyledon like the allele for round seed shape was dominant. Then Mendel planted these seeds and allowed the resulting flowers to self-pollinate. There were two expected possibilities. The allele for round shape and yellow cotyledons which had been inherited from one parent might be inseparable and thus passed on as a single unit to the F₂ generation. If the

same were also true for wrinkled green alleles, one would expect that three-fourth of F₂ generation would be round yellow and one-fourth wrinkled green. On the other hand, if the alleles for seed shape and cotyledon color were distributed to the gametes independently of each other.



So in F₂ generation, some peas were round with green cotyledons and some were wrinkled with yellow cotyledons. Thus four phenotypes were produced in the ratio of 9 : 3 : 3 : 1. These results led Mendel to present his Law of Independent Assortment i.e., the distribution of one pair of factors is independent of the distribution of the other pair.

Q.9.(a) What is aging? How will you explain this process? (4)

Ans "Aging":

Aging is an inevitable process and despite all the efforts to inhibit or stop it, aging process goes on. It can be defined as "negative physiological change in our body". We identify the adult individual by the following sign of old age, all of them need not to be present e.g., loss of hair pigment, development of small pigmented area in the skin of face and arm, dryness and wrinkling of skin, loss of agility, increase weight due to fat, poor

vision and forgetfulness, general vision and decreased body immunity. Degeneration of organ and tissues may also take place e.g., in joints, arthritis arises from the degeneration of cartilage, degeneration and disappearance of the elastic tissue in the tunica media of the blood vessel results in arteriosclerosis. Blood clotting in the coronary arteries may occur.

The exact process of aging is still unknown but the following points are worth consideration:

- (i) The cells of tissue have only a finite number of mitotic division and hence the cells may have reached their finite number by the time a tissue or an organ is fully grown. For example, in the case of nervous system, mental activity and memory deteriorate and there are fewer nerve cells in old age.
- (ii) Change in intracellular substances take place during aging. For example, collagen acquires increased cross linkage in its protein molecule, while elastic tissue loses its elasticity with the passage of time. There is also hardening and loss of resilience in dense connective tissue and cartilage.
- (iii) Spontaneous mutation may result in loss of cells and degeneration of tissues. The process of aging can be slowed down by better nutrition and improved living conditions e.g., regular exercise, regular meal, adequate sleep, abstinence from smoking and maintaining ideal weight can prolong life by an average of 11 years.

(b) How did eukaryotes evolve from prokaryotes? (4)

Ans The nutrients produced in the primitive environment would have limited early life. If life was to continue, another source of nutrients was needed. Photosynthesis, probably freed living organisms from a dwindling supply of nutrients. The first photosynthetic organisms probably used hydrogen sulphide as a source of hydrogen for reducing carbon dioxide to sugars. Later, water served this same purpose, and oxygen liberated by photosynthetic reactions began to accumulate in the atmosphere. Earth and its atmosphere slowly began to change. Ozone in the upper atmosphere began to filter ultraviolet radiation from the sun, the reducing atmosphere slowly became an oxidizing atmosphere, and at least some living organisms

began to utilize oxygen. About 420 million years ago, enough protective ozone had built up to make life on land possible. Ironically, the change from a reducing atmosphere to an oxidizing atmosphere also meant that life could no longer arise abiotically. The first cells were most likely very simple prokaryotic forms. The prokaryotes may have arisen more than 3.5 billion years ago. Eukaryotes are thought to have first appeared about 1.5 billion years ago. The eukaryotic cell might have evolved when a large anaerobic (living without oxygen) amoeboid prokaryote ingested small aerobic (living with oxygen) bacteria and stabilized them instead of digested them. This idea is known as the endosymbiont hypothesis and was first proposed by Lynn Margulis. According to this hypothesis, the aerobic bacteria developed into mitochondria, which are the sites of aerobic respiration and most energy conversion in eukaryotic cells. The possession of these mitochondria-like endosymbionte brought the advantage of aerobic respiration to the host.

Flagella (whiplike structures) may have arisen through the ingestion of prokaryotes similar to spiral-shaped bacteria called spirochetes. Ingestion of prokaryotes that resembled present-day cyanobacteria could have led to the endosymbiotic development of chloroplasts in plants.

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