23. Reproduction in Organism

1. Introduction

The process in living organisms which ensures its continuity is reproduction. Reproduction is one of the most important characteristic features of living organisms. There is a large diversity in the biological world and each organism has evolved its own mechanism to multiply and produce offsprings. The organism's habitat, its internal physiology and several other factors are collectively responsible for how it reproduce. This chapter deals with the life span of organisms, basic features of reproduction and types of reproduction (asexual and sexual).

2. Life span

Life span can be defined as the period from birth to the natural death of an organism. It can vary from as short few days to as long as a number of years. Life span cannot necessarily be correlated with size of an organism i.e., it will be a mis-concept to say that smaller organisms have shorter life span and larger organisms have longer life span.
Life span of an organism usually possesses four stages:

2.1 Juvenility

During this stage the organism develops the capacity to reproduce.

2.2 Maturity

Reproduction begins during this stage.

2.3 Ageing and Senescence

Ageing is progressive deterioration in the body of the organisms. The terminal irreversible stage of ageing is called senescence.

2.4 Death

Senescence finally leads to death.

- **Maximum life span** is the maximum number of years survived or the greatest age reached by any number of a species.
- **The average life span** refers to the average number of years survived or age reached by the members of a population.
- **Life expectancy**, the number of years an individual can expect to live for, is based on average life span. It is defined as the age at which half the population still survives. Thus, maximum life span is the characteristic of species and life expectancy is the characteristic of a population.
- Average life span and life expectancy of humans have grown dramatically. In general the rate of mortality of humans has gone down and the life span has increased. It is 56 in India whereas in the United State, it is 78.
- Limited life span means that the death of every organism is inevitable i.e., all individuals are mortal except single celled organisms. Despite the limited life span and the mortality of organisms, a variety of plant and animal species are well maintained on earth through the process of reproduction. Reproduction ensures the continuity of different species.
- The maximum life span of wild animals is very difficult to estimate because signs of senility or extreme old age or seldom seen in them. Animals living under natural conditions rarely approach their maximum possible age because of very high death rates due to infant mortality, diseases, predators, bad weather, accidents or competition for food and shelter. For this reason, the most reliable information about the duration of the life span comes from zones, where accurate records are kept and animals live under conditions almost ideally suited to prolong life. The life span of some selected animals is shown in the table.

Life span of some selected animals

Name of animals	Maximum life span (Years)	Name of animals	Maximum life span (Years)
Ant queen	15	Squirrel	16
Carp	47	Guinea-pig	7.5
Toad	36	House mouse	3.5
Bullfrog	30	House rat	4.6
Giant salamander	55	Horse	62
Mud puppy	23	Indian Elephant	70
Cobra	28	Hippopotamus	49
Turtle	123	Fin back whale	80
Alligator	68	Dog	20
Giant tortoise	152	Cat	28
Humming bird	8	Lion	30
Parrot	140	Tiger	25
Swan	102	Pig	27
Great horned owl	68	Chimpanzee	45
Eagle	55	Rhesus monkey	29
Turkey buzzard	118		

Important -

Semelparous organisms reproduce only once in their lifetime, such as annual plants (including all grain crops) and certain species of salmon, spiders, bamboos and century plants. Often, they die shortly after reproduction.

Iteroparous organisms produce offsprings in successive (e.g., annual or seasonal) cycles, such as perennial plants. Iteroparous animals survive over multiple seasons (or periodic condition changes).

3. Reproduction

Reproduction is the means of self perpetuation of a race in which new, young, similar looking individuals are formed by the grown up or adult individuals. The adults which give rise to young ones are called parents.

3.1 Functions of reproduction

(1) It replaces the individuals dying due to senescence or ageing.

(2) Individuals removed from population due to predation or diseases are replaced through reproduction.

(3) It introduces variations essential for adaptability and struggle for existence.

3.2 Basic features of reproduction

(1) Replication of DNA.

(2) Division of cells. It may or may not involve meiosis.

(3) Formation of reproductive units.

(4) Elaboration and development of reproductive units to form new young individuals.

3.3 Types of reproduction

There is no single mechanism of reproduction because of the large scale diversity in structure, physiology and habitat of organisms. Broadly speaking, there are two types of reproduction, Asexual and Sexual.

4. Asexual Reproduction

It is the mode of reproduction in which new individuals develop directly from specialised or unspecialised parts of a single parent without involving fusion of gametes or sex cells. Asexual reproduction occurs in both single celled and multi-celled individuals.

- The parent individual splits, buds or fragments to form identical daughter cells or individuals, e.g., Amoeba, Paramecium, Euglena (acellular protists), Sycon, Hydra, and Tubularia. Planaria, Ascidia (metazoans).
- Asexual reproduction is also called agamogenesis or agamogony.
- In this mode of reproduction, somatic cells undergo mitosis during the formation of a new individual. Therefore, it is also called somatogenic reproduction.
- Young ones resulting from asexual reproduction are exactly identical with the parent except in size and are called clones.
- Each individual of a clone is referred to as a ramet. Members of a clone can however, differ later due to development of different mutations.

Important-

The technical term for sexual reproduction in plants is apomixis, derived from apo meaning "without" and mixis meaning "mingling". Apomixis thus refers to the fact that asexual reproduction lacks the mixing of genes that occurs in sexual reproduction. In apomixis, a new individual is produced by a single parent without pollination or mixing of genetic material. A familiar example of apomixis is the production of new plants by the growth of horizontal stems (runners) in strawberries (genus fragaria). Other familiar plants with asexual reproduction include blackberries (genus rubus) and dandelions (genus taraxacum), both of which produce asexually formed seeds.

Asexual reproduction occurs by fission, budding and fragmentation.

4.1 Binary Fission

It is a mode of asexual reproduction in which the body of a mature individual divides into two or more similar and equal sized daughter individuals. Fission can be binary fission or multiple fission.

(1) **Binary fission :** It is the division of the body of an individual into two equal halves, each of which functions as an independent daughter individual. In unicellular organisms, binary fission is accompanied by mitotic division of nucleus followed by cytokinesis. In metazoans, the multicellular individual divides into two daughters by a sort of construction or cleavage.

The organisms which undergo binary seldom die of senescence or old age because as soon as they mature, they divide into two daughters. They are therefore, nearly immortal. Depending on the plane of division, binary fission is of the following types :

- **Simple binary fission (Irregular binary fission)** : Division can occur through any plane e.g., Amoeba.
- **Longitudinal binary fission** : The plane of fission passes along the longitudinal axis of the animal, e.g., Euglena, Vorticella.
- **Oblique Binary fission** : The plane of binary fission lies at an angle to the transverse axis e.g., Ceratium, Gonyaulax.
- **Transverse Binary fission** : The plane of binary fission runs along the transverse axis of the individual, e.g., Paramecium, diatoms, bacteria. In Paramecium, transverse binary fission is proceeded by amitotic division of meganucleus and mitotic division of micronucleus. In it, binary fission produces two dissimilar daughters, one proter (anterior) and the other opisthe (posterior). Both develop the deficient components and become similar.

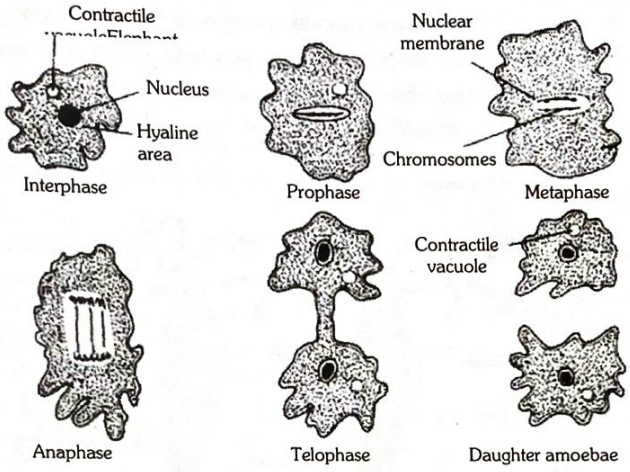


Figure : Binary Fission in Amoeba

(2) Multiple fission : The nucleus divides several times by amitosis to produce many nuclei, without involving any cytokinesis. Later, each nucleus gathers a small amount of cytoplasm around it and the mother individual splits into many tiny daughter cells (e.g., Amoeba, Plasmodium, Monocystis etc.). In course of time, each of these daughter cells starts a free life and transforms into an adult individual. This kind of fission is called multiple fission.

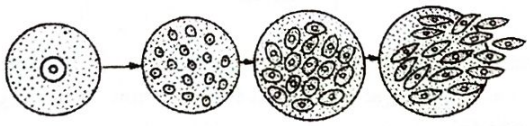


Figure : Multiple Fission in Plasmodium

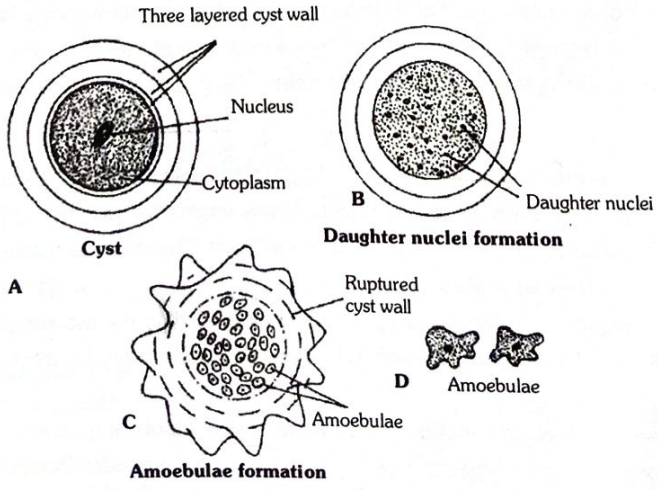


Fig. : Multiple Fission in Amoeba

Multiple fission in *Plasmodium*: In response to unfavourable living conditions, an Amoeba withdraws its pseudopodia and secretes a three-layered hard covering or cyst around itself. This phenomenon is termed as encystations. During favourable conditions, the encysted Amoeba divides by multiple fission and produces many minute amoebae or pseudopodiospores; the cyst wall bursts out and the spores are liberated in the surrounding medium to grow up into many Amoebae. This phenomenon is known as sporulation. Acellular protists like sporozoans (e.g., Monocystis, Plasmodium, etc.) typically exhibit sporulation in their life cycles.

4.2 Budding

In budding, new individuals are formed by mitosis. Initially, a small outgrowth of the parent's body develops into a miniature individual. It then separates from the mother to lead a free life (e.g., Hydra). This type of budding is known as Exogenous budding.

- Sometimes, the buds do not get separated from the mother individual and form a colony. For example, in Obelia, the colony consists of a number of individuals or zooids that perform different functions.
- In all fresh water sponges (e.g., Spongilla) and some marine sponges (e.g., sycon), the parent individual releases a specialised mass of cells enclosed in a common opaque envelope, called the gemmule. And it is known as Endogenous budding.
- On germination, each gemmule gives rise to an offspring and the archeocytes present in it give rise to various cells of the body of sponge as they are totipotent. Gemmules are thought to be internal buds.

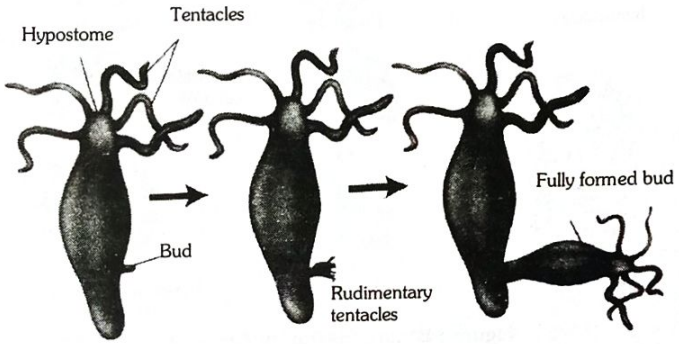


Figure : Exogenous budding in Hydra

4.3 Sporulation

The process of formations of spores is known as sporulation. It is a mode of asexual reproduction in Monera, Protista, Algae and Fungi. These spores germinate to produce new individuals.

4.4 Fragmentation

Some species are designed to have many viable parts that can live independently all found on one individual. These types species can undergo a type of asexual reproduction known as fragmentation. The body of the parent breaks into distinct pieces, each of which can produce an offspring (e.g., Hydra, Some marine worms, sea-stars).

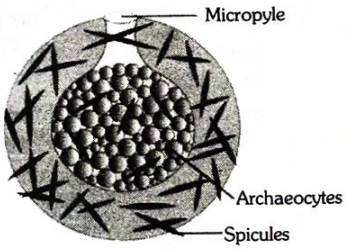


Figure :Gemmule

4.5 Regeneration

When a lizard loses its tail, it grows a new one. This is called regeneration. In many organisms, there are specialized cells, which can differentiate and grow into a new organism. Organisms like hydra and planaria also show regeneration. In these organisms, when the cell divides into numerous pieces, each piece proliferates and differentiates to regenerate new organisms.

4.6 Vegetative Propagation

It is a specialised type of asexual reproduction occurring in higher plants especially angiosperms. In this process, genetically identical new plants are formed from vegetative parts of parent plants. These vegetative part are called as vegetative propagule. Methods of vegetative propagation are categorised into natural and artificial methods. These are as follows

1. **Natural vegetative propagation in higher plants**

   This type of vegetative propagation occurs in plant naturally. A fragment of the mother plant separates and forms an independent plant under suitable conditions. Natural propagation in higher plants may occur by the following means

   (i) By roots

   Tap root branches can develop adventitious buds and form new plants, e.g. guava, Populus and Dalbergia. Similarly, fleshy adventitious roots also take part in vegetative propagation, e.g. sweet potato, Dahlia and Asparagus.

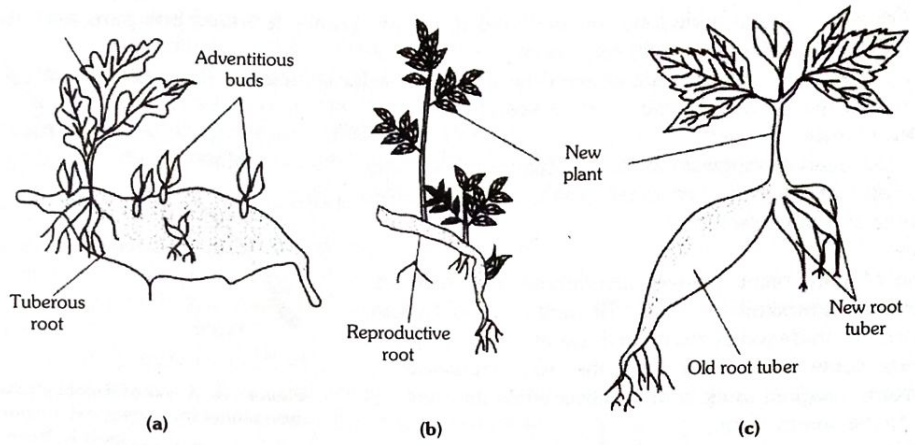


Figure - Vegetative propagation by roots :

(a) Adventitious buds growing into new shoots from tuberous root of sweet potato,
(b) Young shoots arising from reproductive root of Dalbergia (Sheesham),
(c) Old root tuber of Dahlia growing into new plant

(ii) By stems

In plants, vegetative propagation can also take place by stems. They modify variously to give rise to new plants.

(a) Underground stems

Various underground stems are given below

- Tuber is modified swollen underground stem. It bears buds on eyes or nodes. Each bud may grow into a new plant when planted, e.g. potato and artichoke.
- Rhizome is an underground stem having buds, nodes and internodes. Buds present on nodes give rise to new aerial shoot, e.g. banana, ginger and Aspidium.
- Bulbs are modified shoots bearing apical and axillary buds that give rise to new plants, e.g. Narcissus, onion and garlic.
- Corms bear buds that sprout to form new plants, e.g. Crocus, Colocasia and Freesia.

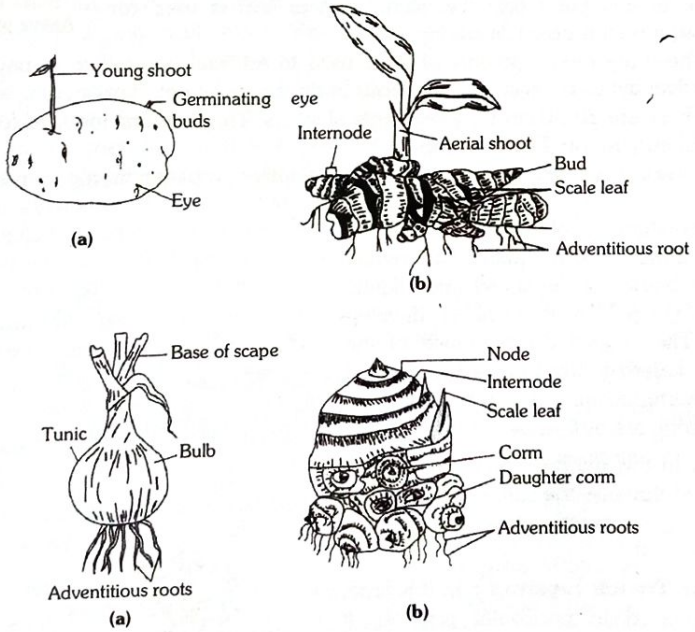


Figure :(a) Tuber of potato, (b) Rhizome of ginger, (c) Bulb of onion, (d) Corm of Colocasia

(b) Subaerial stems (Creeping stems)

These stems creep over the surface of soil. The various types of stems used in the development of new plants are as follows

- Runners are specialised narrow, green horizontal branches. They develop at the base of roots from where new crowns are formed, e.g. coriander, Centella and Oxalis.
- Stolons are horizontal branches that arches above the ground. They also help in vegetative propagation, e.g. strawberry, Vallisneria.

- Offset is one internode long runner found in aquatic plants. It breaks into parts and then forms new plants, e.g. Eichhornia (water hyacinth) and Pistia.
- Suckers arise from the base of erect shoots and grow for sometime. These detach from parent plants and then give rise to new shoots, e.g. mint and Chrysanthemum.

(c) Aerial shoots

The bud bearing segments of some stems may directly give rise to new plants when fall down, e.g. sugarcane, Opuntia and other cacti.

(iii) By leaves

The leaves of many plants possess adventitious buds that help in vegetative propagation, e.g. Begonia, Bryophyllum, Saintpaulia, etc. In Begonia, the injured leaves form new plants when they come in contact with the soil. However, in Bryophyllum, marginal buds form plantlets while they are still attached to the parent plant.

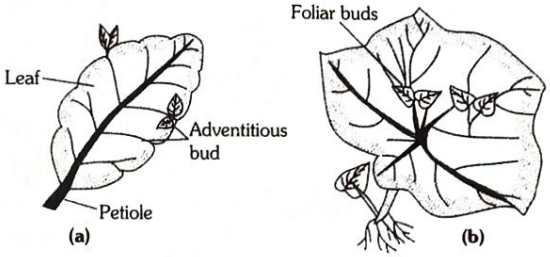


Figure : (a) A leaf of Bryophyllum showing formation of new plants from marginal adventitious buds, (b) Foliar buds in Begonia

(iv) By bulbils

These are multicellular fleshy floral buds. They are produced in the axil of foliage leaves in place of axillary buds. These grow and form new plants when they shed and fall on the ground, e.g. Oxalis and Allium sativum. In century plant (Agave sp.), the floral buds can modify into bulbils and grow into new plants, while they are present on mother

(v) By turions

These are special types of fleshy buds that develop in aquatic plants. They are swollen and contains reserve food material. During the spring it forms new plant for vegetative propagation, e.g. Potamogeton and Utricularia.

Figure : Bulbils of Agave plant.

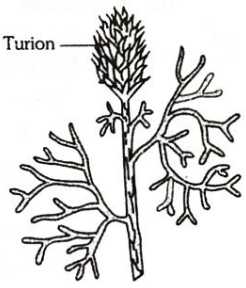


Figure : Turion of Utricularia

2. Artificial method of vegetative propagation

In this method, parts of somatic body of a plant is used to develop into new independent plant. These are as follows

(i) By the use of special vegetative parts

Many plants are multiplied vegetatively by using their specialised vegetative structures like root tubers (e.g. sweet potato and Dahlia), corm (e.g. Crocus, Colocasia and Gladiolus), bulb (e.g. garlic and onion), part of rhizome (e.g. banana and ginger), stem tuber (e.g. potato) and bulbil (e.g. pineapple).

(ii) By cuttings

When a small piece of any plant part, i.e. stem, root or leaf is used for vegetative propagation it is called as cutting.

(a) Root cuttings These are long segments of roots used in artificial vegetative propagation. These segments must have ability to form adventitious roots and adventitious buds, e.g. raspberry, lemon, etc.

(b) Stem cuttings These are 20-30 cm long segments of stems. They are first induced for root production by using NAA or IBA, e.g. rose, Clerodendron, Duranta, etc.

(c) Leaf cuttings These are segments of leaves used in vegetative propagation, e.g. Sansevieria.

(iii) By layering

In this method, adventitious roots are induced on a stem, while it is still attached to the plant. The middle part of a soft basal branch is defoliated and slightly injured. It is then pegged in the soil to develop adventitious roots. The pegged down branch of the plant is called layer. Later on, this branch is separated and planted, e.g. cherry, jasmine and grapevine. The various types of layering are as follows

(a) Tip layering : In this method, only the tip of a branch is pegged down in the soil. It induces root formation and later growth of shoot tip, e.g. raspberry, blackberry.

(b) Continuous or Trench layering : In this type, a branch is pegged in horizontal position. It develops a number of vertical shoots, e.g. apple and pear.

(c) Serpentine layering : The basal branch is pegged at several places so as to form many plants, e.g. Clematis.

(d) Mound layering : Shoot is pruned and its lower part is covered by soil in the form of a mound. After sometime it develops a number of shoots. Among these the rooted ones are separated and planted, e.g. gooseberry and currant.

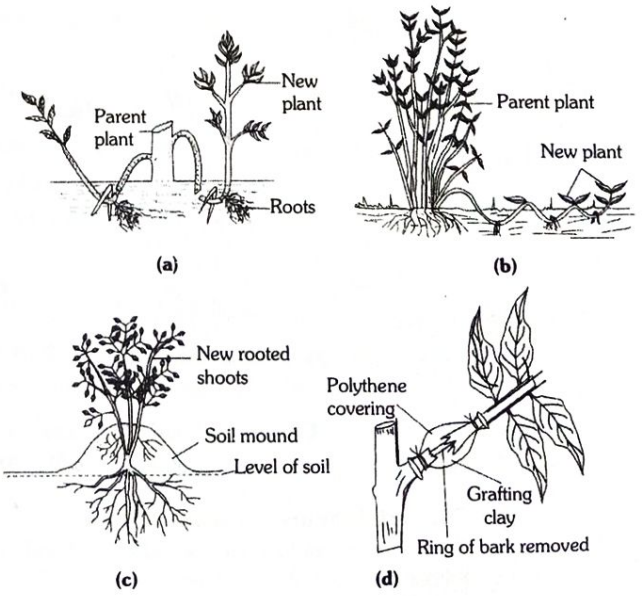


Figure : (a) Tip layering, (b) Serpentile layering, (c) Mound layering,(d) Air layering

(e) Air layering (gootee): In this method, about 3.5 cm ring of bark is removed from the base of an aerial shoot. This area is then covered by a thick plaster of grafting clay. It consists of hay, cowdung, clay and water with small quantity of root promoting hormone such as NAA or IBA. It is then wrapped in polythene. After 2-3 months, roots appear and the shoot is removed below the bandaged region and is used for planting, e.g. litchi, pomegranate, guava, orange and lemon.

Note :Plants having scattered vascular bundles like sugarcane cannot be propagated by air layering. This is because vascular bundles may be harmed in this method and water and food supply will be affected.

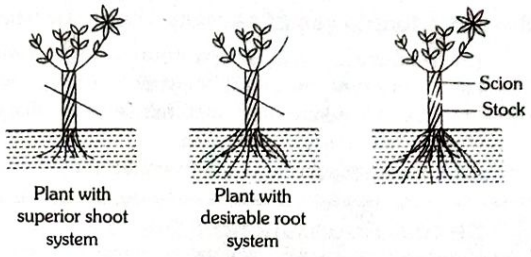


Figure : The process of grafting

(iv) By grafting

It is the most common method of artificial vegetative propagation. In this method, parts of two plants usually roots and shoots are joined in such a way that they grow as one plant. Due to joining the cambia of these plants come in contact. The point of contact is covered with grafting wax and bandages. Grafting is done between the two closely related dicotyledonous plants having vascular cambia. The rooted supporting portion of one plant is called as stock. It is joined with a twig of another plant called scion. Usually eustelic plants are used in this process, e.g. mango, rose, apple, rubber, citrus, pear, plum and peach.

Grafting is of following four types

(a) Tongue or Whip grafting Both the stock and scion are cut obliquely at about the same angle.

(b) Wedge grafting A V-shaped notch is made on stock and wedge-shaped cut is made on the scion.

(c) Crown grafting Several scions having wedge-shaped cut are grafted on the slits at the top of stock.

(d) Side grafting Single scion having wedge-shaped cut is inserted in a lateral slit of the stock.

In case of tongue and wedge grafting, the scion and stock have almost the same diameter, whereas in case of crown and side grafting, the stock has larger diameter than that of scion.

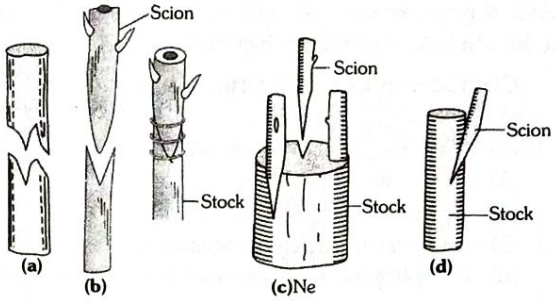


Figure :(a) Tongue grafting, (b) Wedge grafting, (c) Crown grafting, (d) Side grafting

Note

- Grafting can be done only in gymnosperms and dicots. It is not possible in monocot due to the absence of cambium.
- Grafting helps to grow the better varieties of plants with weak roots, e.g. mango, orange, etc.

Bud grafting : In this method, scion is a bud with small portion of bark having intact cambium. This bud is inserted into a T-shaped incision made in the stock in such a way that it reaches upto the cambium of stock. The bud portion remains exposed to the air. The joint is thoroughly sealed using bandage. After 3-5 weeks, the bud begins to grow. As soon as the bud sprouts, the stock is cut above the level of graft, e.g. rose, apple, peach, etc.

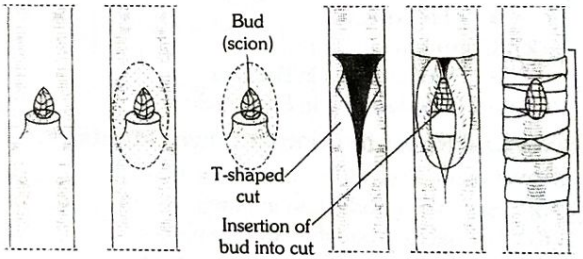


Figure : Bug grafting

- **Micropropagation (propagation by Plant Tissue Culture)**

Differences between Binary fission and Budding

Binary fission	Budding
1. A type of fission.	1. A type of vegetative propagation.
2. The parent body divides into two equal and similar halves, each half forms a new individual.	2. The parent produces a small bud that gradually grows in size and then separates from the body.
3. A protuberance is not formed.	3. A protuberance (bud) is formed.
4. Division is equal.	4. Division is unequal.
5. Parent's body disappears. examples: bacteria, Amoeba, Euglena, Paramecium, Planaria.	5. Parent's body remains intact. example: Yeast, sycon, hydra
6. It is a natural process.	6. Can be induced artificially.

4.7 Advantages of asexual reproduction

(1) It is uniparental.
(2) It is a rapid mode of reproduction.
(3) The young ones are exact replicas of their parent.
(4) Asexual reproduction is simpler than sexual reproduction.

4.8 Disadvantages of asexual reproduction

(1) As there is rapid multiplication, a large number of young ones are formed which causes overcrowding.
(2) There is no mixing of genetic material, so no new combination or variation takes place.
(3) There is no crossing over, hence new linkages are not formed.
(4) It has no role in evolution.
(5) Adaptability to changes in environment is low due to absence of new variations.

5. Sexual Reproduction

Sexual reproduction is the production of offsprings by the fusion of specialised male and female cells called gametes. Gametes are haploid and fuse to form the fertilized egg or zygote which eventually develops into a new organism.
In comparison to asexual reproduction, it is a slow process.
Sexual reproduction has the biological advantage of promoting genetic variety among the members of a species because the offspring is the product of genes contributed by both the parents. By making possible the genetic recombination of inherited traits of two parents, sexual reproduction gives rise to offsprings that may be better able to survive than parents.

5.1 Characteristics of Sexual Reproduction

(1) It is usually biparental.
(2) Gametes are always formed,
(3) Fertilization takes place,
(4) It involves both meiosis and mitosis,
(5) Daughter organisms genetically differ from the parents,
(6) Multiplication is not as rapid as in asexual reproduction.

5.2 Modes of sexual Reproduction

(1) Syngamy : On the basis of occurrence, syngamy may be of two types

- Exogamy
- Endogamy

On the basis of structure of fusing gamete, syngamy may be of four types

- Isogamy
- Anisosgamy
- Oogamy
- Hologamy

(2) Conjugation

- Conjugation in Bacteria
- Conjugation in Paramecium

5.3 Sexual Reproduction in Lower Plants

(1) Sexual Reproduction in Algae
(2) Sexual Reproduction in Fungi
(3) Sexual Reproduction in Bryophytes

5.4 Sexual Reproduction in Higher Plants

(1) Deviation in reproductive strategies in plants

- Parthenogenesis
- Parthenocarpy
- Polyembryony
- Apomixis
- Apogamy

5.5 Sexual Reproduction in Higher Animals

(1) Deviation in reproductive strategies in plants

- Neoteny
- Paedogenesis
- Androgenesis
- Gynogenesis
- Parthenogenesis

5.6 Events in sexual reproduction

The entire sexual process can be divided into three phases Pre-fertilization events, Syngamy or fertilization and Post-fertilization events.

(1) Pre-fertilization events- Pre fertilization events include two processes. Formation of gametes or gametogenesis, Gamete transfer

- **Gametogenesis -**The process of formation of gametes is known as gametogenesis. Gametes are of two types – male and female and are always haploid. In animals, the male gametes, called sperms are produced in the testes whereas the female gametes or the eggs develop in the ovaries. In comparison to male gametes, female gametes are always produced in much smaller number.

- **Sexuality in organisms** Animals are either unisexual (ants, wasps, bees, mosquito, cockroach, frog, birds, rabbit, humans) or bisexual (or hermaphrodite, e.g., earthworm, tapeworm, leech etc.)
- Most hermaphrodites do not reproduce by self-fertilization. For example, in earthworms, two animals copulate and each inseminates the other. In some hermaphrodites, self-fertilization is prevented by development of testes and ovaries at different times.
- **Cell division during gametogenesis** Most of animals have a diploid body, hence they form gametes by meiotic division. A few animal species (e.g., ants, bees, wasps) show an unusual type of sex differentiation. The males are haploid and make haploid sperms by mitosis. The females are diploid and make haploid eggs by meiosis. If an egg is fertilized, it develops into female while unfertilized eggs develop into males.
- Meiosis is an essential feature of sexual cycle. It results in the formation of daughter cells, each with half the number of chromosomes of the parent cell. During fertilization, the nuclei of two gamete cells fuse and the zygote thus formed has a fixed number of chromosomes for each species.
- In all organisms, this number of chromosomes represents the diploid condition (2n). If meiosis does not occur, fusion of gametes would result in doubling of the chromosomes for each successive sexually reproduced generation. This situation is prevented by reduction in the diploid number of chromosomes (2n) to haploid number (n) during gametogenesis.

Chromosome numbers of some eukaryotes

	Organism	Somatic chromosome number		Organism	Somatic chromosome number
I.	**Plants**		IV.	**Animals**	
	Haplopappus gracilis	4	A.	**Vertebrates**	
	Garden pea	14		Frog	26
	Maize	20		Rate	42
	Rice	24		Man	46
	Tomato	24		Chimpanzee	48
	Wheat	42		Gorilla	48
	Sugarcane Ophioglossum	80		Cow	60
	(Adder's tongue fern)	1260		Horse	64
				Dog	78
				Chicken	78
			B.	**Insects**	
				Fruit fly (drosophila)	8
				Honey bee (male)	16(n)
				Honey bee (female)	32(n)
				Periplaneta Americana	33
				(male)	34
				(female)	56
				Silkworm	224
				Geometrid moth	11
				C.roundworm (male)	
				Caenorhabditis Sp. (female)	12
II.	Fungi (normally haploid)				
	Penicillium sp.	4			
	Neurospora	7			
	Yeast (Saccharomyces)	17			
III.	**Protists** (normally haploid)				
	Slime mold	7			
	(Dictyostelium)	250			
	Amoeba proteus				

- **Gamete transfer** - After the formation of gametes, it is essential that male and female gametes are brought together in physical contact. In a majority of organisms, male gamete is motile and the female gamete is stationary. Exceptions are a few fungi and algae in which both types of gametes are motile and they differ only in certain surface proteins. They are usually released in water and move towards each other chemotactically. They however, cannot recognized each other until they touch.
  - In some other groups of plants (bryophytes and pteridophytes), the male gamete is motile and the female gamete is stationary. Although only one male gamete is required to fertilize the egg (female gamete) but they are produced in very large numbers to ensure fertilization.
  - In seed plants, male gametes develop in the pollen and female gamete or egg lies in the embryo sac within the ovule (megasporangium).
  - To bring male and female gametes together, it is necessary that pollens from anther are transferred to the stigma. This process is known as pollination.

- If the transfer occurs between two plants of different genetic makeup, the process is known as cross-pollination. It is common of think of self-pollination occurring within a single flower on a plant such as garden pea where petals enclose the stamens in such a way that the pollen has little chance of escaping.
- However, self-pollination also occurs if pollen is transferred between different flowers on the same plant. It is helped by insects moving from flower to flower collecting nectar.
- In dioecious animals, male and female gametes are formed in different individuals. For fertilization to occur, sperm and egg must get together. Animals have evolved different strategies for this. For example, many animals secrete sex pheromones to attract their partners.
- Male and female insects like the silkworm moth (Bombyx mori) produce tiny amounts of very volatile pheromones that diffuse very long distances. Only male moths of this species are attracted towards female moths by distinctive alcohol (bombykol) produced by the female.
- Several invertebrates release their gametes into water, thus there is no need for the parents to make direct contact. In others, mating is important to bring male and female gametes in close contact.

(2) **Syngamy and fertilization** - The most important step in the process of sexual reproduction is the fusion of male and female gametes although the terms syngamy and fertilization are used synonymously, but the actual act of fusion of gametes is syngamy whereas fertilization includes all the events that ultimately lead to syngamy. The result of syngamy and fertilization is the formation of a diploid zygote which is the vital link that ensures continuity of species between organisms of one generation to the next generation.

- **External fertilization** -Fertilization may occur inside or outside the female body. animals with external fertilization may or may not undergo mating but it is essential when the fertilization is internal because the male gametes need to be placed close to the egg inside the body. Many marine invertebrates release their gametes in water. The sperms swim to reach the eggs. Frogs have external fertilization, yet a form of mating takes place. A male clings to a female's back for hours, until she releases eggs. Even fishes, which cannot easily hold on to one another, may have courtship leading to pairing of male and female, before eggs are laid and fertilized. Courtship is an important prelude to mating. It gives females an opportunity to assess the quality of a male. Also it allows time for co-ordination of the male and female reproductive organs.
- **Internal fertilization –** It requires direct contact between the two sexes. In most birds, the openings of the reproductive systems are simply brought together through which sperms are transferred. This is a brief encounter, typically a very few seconds. Snails, insects and mammals have developed a special copulatory organ for the delivery of sperms.

(3) **Post-fertilization Events-**In all sexually reproducing organisms, fusion of male and female gametes results in the formation of a zygote. In organisms with external fertilization, zygote is formed outside the body, usually in water as in frogs, bony fish etc. In organisms exhibiting internal fertilization, zygote develops inside the body of the organisms. The post fertilization events include.

- **The Zygote-**Formation of the diploid zygote is universal in all sexually reproducing organisms. In organisms with external fertilization, zygote is formed in the external medium whereas in those exhibiting internal fertilization , zygote is formed inside the body of the organism. Development of zygote depends on the type of the life cycle the organism has and the environment It is exposed to.
- **Embryogenesis** -Development of embryo from the diploid zygote is known as embryogenesis. Embryonic development is a complex process which involves cell division and cell differentiation. These events proceed according to the genetic information contained in the zygote and ultimately lead to the formation of mature animals. How amazing it is that from one fertilized zygote, cells as different as liver, muscle, nerve and skin are produced. These cells differ from one another in that they synthesize different enzymes and structural proteins. The developing embryo grows in size at the expense of food derived from outside. The mammalian embryo is nourished by the placenta.

  Depending upon the development of zygote inside or outside the body of the female parent, organisms have been classified into oviparous or viviparous.

  (a) **Oviparous organisms** lay eggs (e.g., some species of sharks, skates, bony fishes, frog, lizards, birds), the yolk in the egg supplies food to the embryo. In some oviparous organisms (e.g., reptiles and birds), the fertilized eggs are covered by hard calcareous shell or in some cases with a leathery coat. Such eggs are laid in a safe environment where they are incubated for a certain period and the young ones hatch out.

  (b) **In Viviparous organisms**, on the other hand, development of fertilized egg into embryo takes place within the uterus of the female parent and the offspring is born as a juveniles. The embryo in viviparous organisms receives nourishment from the mother's blood through placenta.

  (c) Many species of sharks are ovoviviparous. In such organisms, the eggs are incubated within a modified portion of the oviduct called uterus and the young ones are born alive after hatching. During development, they depend on stored yolk for their nourishment.

23. Reproduction in Organisms – Multiple Choice Questions

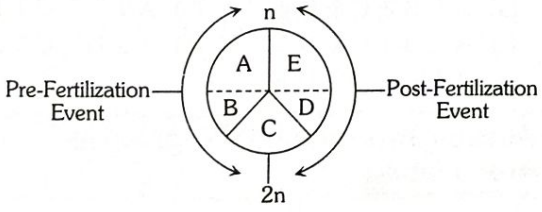
1. Reproduction and its type

1. Which of the following shows the sexual dimorphism
(a) *Hydra* and *Ascaris*
(b) *Hydra* and *Oryctolagus*
(c) *Ascaris* and *Pheretima*
(d) *Ascaris* and *Oryctolagus*

2. Natural parthenogenesis occurs in
(a) Frog to form female
(b) Honeybee to produce drones
(c) Cockroach
(d) Vegetarian eggs

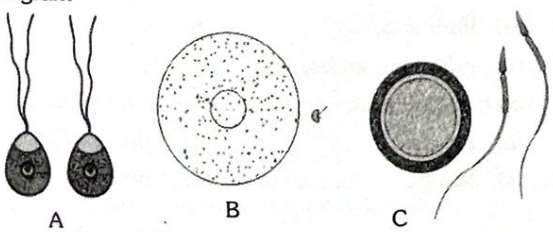
3. Consider the following statements with respect to reproduction in the lower living organisms
A. Organisms like yeast and *Planaria* reproduce asexually by means of budding
B. True regeneration is observed in *Hydra*
C. The protonema of mosses multiply by fragmentation
D. In the unicellular organisms like bacteria algae and *Amoeba*, reproduction is synonymous with growth, i.e, increase in number of cells
Of the above statements
(a) A and B alone are correct
(b) B and C alone are correct
(c) A and D alone are correct
(d) B and D alone are correct
(e) C and D alone are correct

4. Select the right option in which the events (A, B, C, D and E) in life of general reproduction are correctly identified



(a) A - Gametogenesis, B - Zygote formation, C – Fertilization, D - Gamete transfer, E - Embryogenesis
(b) A - Gametogenesis, B - Gamete transfer, C – Fertilization, D - Zygote formation, E - Embryogenesis
(c) A - Gamete transfer, B - Gametogenesis, C – Fertilization, D - Zygote formation, E - Embryogenesis
(d) A - Gametogenesis, B - Gamete transfer, C – Fertilization, D - Embryogenesis, E - Zygote formation

5. Identify gametes (A, B and C) respectively in given diagram



(a) Homogametes, isogametes, heterogametes
(b) Isogametes, homogametes, heterogametes
(c) Heterogametes, isogametes, homogametes
(d) Homo/ Isogametes, Heterogametes, Heterogametes

6. In which of the following animals, parthenogenesis is very common
(a) Monkeys (b) Hens
(c) Ducks (d) Aphids

7. Syngamy is the complete and permanent fusion of two gametes. It includes
(a) Endogamy and Exogamy
(b) Isogamy and Anisogamy
(c) Both (a) and (b)
(d) None of the above

8. Which one of the following glands is absent in reproductive system of rabbit
(a) Cowper's gland (b) Collateral gland
(c) Perineal gland (d) Prostate gland

9. In *Vorticella*, the total number of micronuclei formed at the end of pre-zygotic nuclear division in female gamont is
(a) 4 (b) 6
(c) 8 (d) 5

10. Drones in a colony of honey bees originate by
(a) Thelytoky
(b) Arrhenotoky
(c) Cyclic parthenogenesis
(d) Diploid parthenogenesis

11. A few statements with regard to sexual reproduction are given below
(i) Sexual reproduction does not always required two individuals
(ii) Sexual reproduction generally involves gametic fusion
(iii) Meiosis never occurs during sexual reproduction
(iv) External fertilization is a rule during sexual reproduction Choose the correct statements from the options below
(a) (i) and (ii) (b) (i) and (ii)
(c) (ii) and (iii) (d) (i) and (iv)

12. Asexual method of reproduction by binary fission is common to which of the following
(i) Some eukaryotes (ii) All eukaryotes
(iii) Some prokaryotes (iv) All prokaryotes
Choose the correct option from the following
(a) (i) and (ii) (b) (ii) and (iii)
(c) (i) and (iii) (d) (iii) and (iv)

13. The statements given below describe certain features that are observed in the pistil of flowers
(i) Pistil may produce more than one seed
(ii) Each carpel may have more than one ovule
(iii) Each carpel has only one ovule
(iv) Pistil have only one carpel
Choose the statement that are true from the options below
(a) (i) and (ii) (b) (i) and (iii)
(c) (ii) and (iv) (d) (iii) and (iv)

14. Which of the following situations correctly describe the similarity between an angiosperm 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 mobile
(iv) Syngamy in both results in the formation of zygote
Choose the correct answer from the options given below
(a) (ii) and (iv) (b) (iv) only
(c) (iii) and (iv) (d) (i) and (iv)

15. 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)

16. 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

17. 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 seeding will be, respectively
(a) 12, 24, 12 (b) 24, 12, 12
(c) 12, 24, 24 (d) 24, 12, 24

18. Given below are a few statements related to external fertilization. Choose the correct statements
(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 fertilization
(iv) Offspring formed as a result a external fertilization have better chance of survival than those formed inside an organism
Choose the correct option
(a) (iii) and (iv) (b) (i) and (iii)
(c) (ii) and (iv) (d) (i) and (iv)

19. 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), (ii) and (iii) (b) (i), (iii) and (iv)
(c) (i), (ii) and (iv) (d) (ii), (iii) and (iv)

20. 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

21. There is no natural death in single celled organisms like Amoeba and bacteria because
(a) They cannot reproduce sexually
(b) They reproduce by binary fission
(c) Parental body is distributed among the offspring
(d) They are microscopic

22. 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

23. 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

24. 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 shell be
(a) 20 (b) 10
(c) 40 (d) 15

25. In rabbit, ex-abdominal reproductive organs are
(a) Testes, Penis, Epididymis
(b) Testes, Vas deferens, Testis sac
(c) Testes, Vas deferens, Ejaculatin duct
(d) Testes sac, Seminal Vesicle, Epididymis

26. Match the following and choose the correct combination from the options given

Column I (Organism)	**Column II (Approximate life span)**
A. Butterfly	1. 60 years
B. Crow	2. 140 years
C. Parrot	3. 15 years
D. Crocodile	4. 1–2 weeks

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

2. Asexual reproduction/Vegetative propagation

1. The part which is grafting on stalk of another tree is called
(a) Graft (b) Bulbil
(c) Bud (d) scion

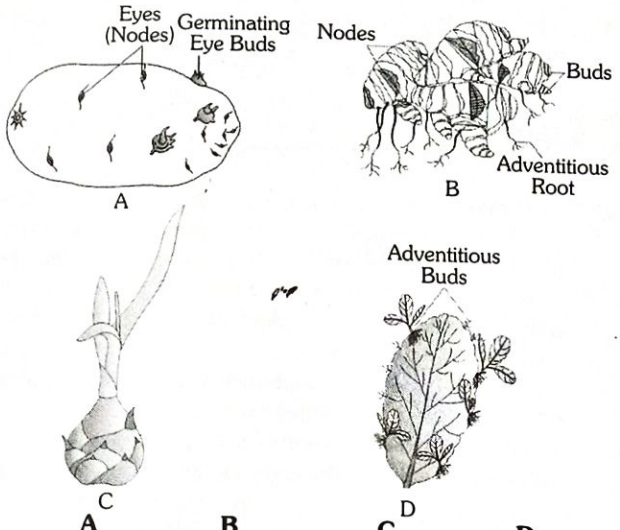
2. Among the following which one is not a method of vegetative propagation
(a) Budding (b) Layering
(c) Sowing (d) Tissue culture

3. Vegetative reproduction by layering is found in
(a) Jasmine (b) Mango
(c) Rose (d) All of these

4. Development of embryo from the cells of the nucellus is called
(a) Parthenocarpy (b) Apocarpy
(c) Adventive embryony (d) Apospory

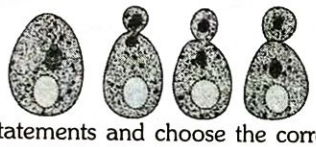
5. Stem cuttings are commonly used for the propagation of
(a) Banana (b) Rose
(c) Mango (d) Cotton

6. Study the diagrams given below and select the right options out of (a - d); in which all the 4 items A, B, C and D are correctly identified



	A	B	C	D
(a)	Offset	Sucker	Stolon	Leaf buds
(b)	Offset	Sucker	Stolon	Leaf buds
(c)	Tuber	Rhizome	Bulb	Leaf buds
(d)	Tuber	Rhizome	Bulbil	Leaf buds

7. The given diagram refers to which type of reproduction in yeast



(a) Layering
(b) Budding
(c) Binary fission
(d) Fusion

8. Consider the following statements and choose the correct option
(i) The genetic constitution of a plant is unaffected in vegetative propagation
(ii) Rhizome in ginger serves as an organ of vegetative reproduction
(iii) Totipotency of cells enables us to micropropagate plants
(a) Statements (i) and (ii) alone are true
(b) Statements (ii) and (iii) alone are true
(c) Statement (ii) alone is true
(d) Statement (iii) alone is true
(e) All the three statements [(i) (ii) and (iii)] are true

9. Genetically identical progeny is produced when an individual
(a) Practices self-fertilization
(b) Produces identical gametes
(c) Practices reproduction
(d) Practices by breeding without meiosis

10. The development of gametophyte from the vegetative parts of the sporophyte without the intervention of spores is called

Or

The formation of gametophyte from the sporophyte (without meiosis) is called
(a) Parthenocarpy (b) Parthenogenesis
(c) Apogamy (d) Apospory

11. Grafting of tissue or organ between individuals of different species is called
(a) Autograft (b) Isograft
(c) Xenograft (d) Allograft
(e) Intergraft

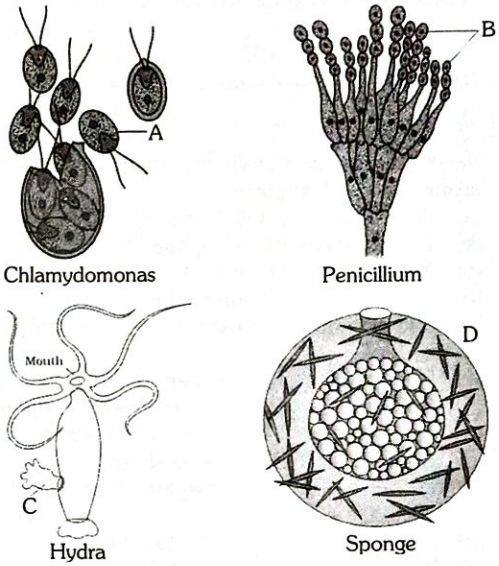
12. Appearance of vegetative propagules from the nodes of plants such as sugarcane and ginger is mainly because
(a) Nodes are shorter than internodes
(b) Node have meristematic cells
(c) Nodes are located near the soil
(d) Nodes have non-photosynthetic cells

13. 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

14. Virus free culture of banana can be raised from
(a) Apical cells (b) Pith of stem
(c) Leaf lamina (d) Primary root

15. In *Sansevieria,* the mode of vegetative propagation is through
(a) Stem cuttings (b) Leaf cuttings
(c) Rhizome cuttings (d) None of these

16. Identify A to D in given figures showing asexual reproductive structure



(a) A- Zoospore, B - Conidiosporangium, C - Bud, D - Gemmule
(b) A - Zoospore, B - Conidia, C - Bud, D - Gemmule
(c) A - Zoogamete, B - Conidia, C - Bud, D - Gemmule
(d) A - Aplanospore, B - Conidia, C - Bud, D – Gemmule

17. Match the following

	Column I		Column II
A.	Virus free	I.	Intact roots
B.	Root cutting	II.	*In vitro*
C.	*Dalbergia*	III.	Blackberry
D.	Mound layering	IV.	Jasmine

(a) A-I, B-III, C-II, D-IV (b) A-II, B-III, C-I, D-IV
(c) A-II, B-I, C-III, D-IV (d) A-II, B-III, C-IV, D-I

3. NEET

1. A person which shows the secondary sexual characters of both male and female is called **[1996]**
(a) Intersex (b) Hermaphrodite
(c) Bisexual (d) Gynandromorph

2. Product of sexual reproduction generally generates **[2013]**
(a) Large biomass
(b) Longer viability of seeds
(c) Prolonged dormancy
(d) New genetic combination leading to variation

3. 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

4. Which of the following pairs is not correctly matched **[2015]**

Mode of reproduction	Example
(a) Rhizome	Banana
(b) Binary fission	*Sargassum*
(c) Conidia	*Penicillium*
(d) Offset	Water hyacinth

5. Vegetative propagation in mint occurs by **[2009]**
   (a) Runner (b) Offset
   (c) Rhizome (d) Sucker

6. Vegetative propagation in *Pistia* occurs by **[2010]**
   (a) Stolen (b) Offset
   (c) Runner (d) Sucker

7. To get haploid callus, one can culture **[2001]**
   (a) Embryo (b) Leaf tissue
   (c) Stigma (d) Pollen grain

8. In which one pair both the plants can be vegetatively propagated by leaf pieces **[2005]**
   (a) *Bryophyllum* and *Kalanchoe*
   (b) *Chrysanthemum* and *Agave*
   (c) *Agave* and *Kalanchoe*
   (d) *Asparagus* and *Bryophyllum*

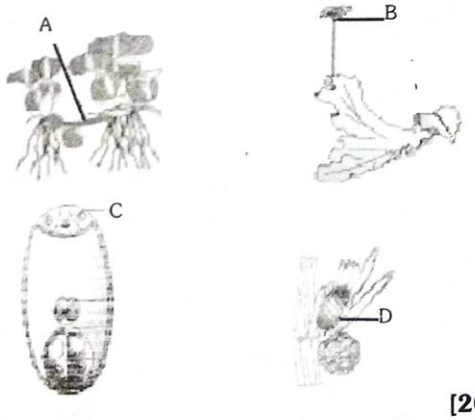
9. What is common between vegetative reproduction and Apomixis **[2011]**
   (a) Both occur round the year
   (b) Both produces progeny identical to the parent
   (c) Both are applicable to only dicot plants
   (d) Both bypass the flowering phase

10. Which of the following propagates through leaf-tip **[2004]**
    (a) *Marchantia* (b) Moss
    (c) Walking fern (d) Sprout-leaf plant

11. The reason of formation of embryoid from pollen grain in a tissue culture medium is **[2002]**
    (a) Organogenesis (b) Double fertilization
    (c) Test tube culture (d) Cellular totipotency

12. Examine the figures (A-D) given below and select the right option out of a-d, in which all the four structures A, B, C and D are identified correctly

Structures :



[2010]

Options:

	A	B	C	D
(a)	Rhizome	Sporangiophore	Polar cell	Globule
(b)	Runner	Archegoniophore	Synergid	Antheridium
(c)	Offset	Antheridiophore	Antipodals	Oogonium
(d)	Sucker	Seta	Megaspore mother cell	Gemma cup

13. Offsets are produced by **[2018]**
    (a) Parthenogenesis (b) Parthenocarpy
    (c) Mitotic divisions (d) Meiotic divisions

14. Sweet potato is a modified **[2018]**
    (a) Rhizome (b) Tap root
    (c) Adventitious root (d) Stem

4. AIIMS

1. Gemmule formation in sponges is helpful in **[2001]**
   (a) Parthenogenesis (b) Sexual reproduction
   (c) Only dissemination (d) Asexual reproduction

2. After culturing the anther of a plant, a few diploid plants were found along with haploid plants. The diploid plants could have arisen from **[1993]**
   (a) Generative cell of pollen (b) Cells of anther wall
   (c) Vegetative cell of pollen (d) Exine of pollen wall

3. The development of a sporophyte without fertilization from the vegetative cells of the gametophyte is called **[2001]**
   (a) Zygospory (b) Aplanospory
   (c) Apospory (d) Apogamy

4. The plant material which is widely used in the preparation of culture medium is **[1998]**
   (a) *Cycas revoluta* (b) *Cocus nucifera*
   (c) *Pinus longifolia* (d) *Borassus flabellifer*

5. By tissue culture, indefinite number of plants from a small amount of parental tissue can be obtained. This technique is of great economic importance as **[1994]**
   (a) New species can be generated
   (b) Through somaclonal variation, a large number of variants can be isolated
   (c) It is a useful method to multiply genetically uniform population of elite species
   (d) Homozygous diploids can be obtained

5. Assertion and Reason

Read the assertion and reason carefully to mark the correct option out of the options given below :
(a) If both the assertion and the reason are true and the reason is a correct explanation of the assertion
(b) If both the assertion and reason are true but the reason is not a correct explanation of the assertion
(c) If the assertion is true but the reason is false
(d) If both the assertion and reason are false
(e) If the assertion is false but reason is true

1. Assertion : Asexual reproduction is also called blastogenesis.
   Reason : In asexual reproduction, there is no formation and fusion of gametes.

2. Assertion : Many plants are propagated vegetatively even though they bear seeds.
   Reason : Potatoes multiply by tubers, apple by cutting.

3. Assertion : Claspers of cartilage fishes are analogous to penis of human male.
   Reason : Both act as copulatory organs and transfer the sperms into female.