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Chapter

23 REPRODUCTION IN ORGANISMS

BR Brief Review

Reproduction is the formation of new similar young living organisms by grown up individuals. Reproduction provides group immortality or perpetuation of species because individuals are bound to die after a life span.

• Life Span

The period between birth and natural death of an organism is called **life span**. Life span varies from less than one day to more than 4000 years. Life spans are not related to size or complexity of the organisms. Crows and parrots are of equal size. Crow has a life span of only 15 years, while parrot lives for about 140 years. Similarly, Mango tree lives for about 200 years while Peepal (*Ficus religiosa*) has a life span of about 2500 years. Banyan tree (*Ficus bengalensis*) spreads over a very large area but does not live beyond 500 years.

Life Span of Some Organisms

1. Butterfly — 1–2 weeks **2.** Fruitfly — 1 month **3.** Rice plant — 4 months
4. Rose bush — 10 years **5.** Crow — 15 years **6.** Banana plant — 25 years
7. Dog — 20–25 years **8.** Cow — 25 years **9.** Horse — 50 years
10. Crocodile — 60 years **11.** Elephant — 75 years **12.** Tortoise — 100–150 years
13. Parrot — 140 years **14.** Banyan tree — 300-500 years.

• Types of Reproduction

Depending upon the formation or non-formation of gametes, reproduction is of two types, sexual and asexual.

• Asexual Reproduction

It is a mode of reproduction or formation of new young individuals from a specialised or unspecialised part of single parent without the formation and fusion of gametes. Besides being **uniparental** and absence of gametes, asexual reproduction is characterised by divisions through mitosis only, genetic similarity between parent and young ones, rapidity and absence of haploid-diploid alteration. Asexual reproductive propagule is called **blastos.** It contains totipotent cells like meristematic cells (plants) archaeocytes (sponges), interstitial cells (cnidaria), parenchyma (platyhelminthes) and neoblast (annelids), etc. An individual produced through asexual reproduction is **ramet. Clone** is group of al genetically similar individuals formed through asexual reproduction. The parent or ancestor of a clon is called **ortet.** Clones have been prepared artificially in the laboratory by scientists, *e.g.*, boar ca named Frosty and Fin Dorset lamb named Dolly.

1. Fission. It is a type of asexual reproduction in which the body of an individual undergo division to produce two or more equal sized daughters. (*i*) **Binary Fission.** The mature individu divides into two equal sized daughter individuals. Binary fission is **irregular** or **simple** (can occur any plane) in *Amoeba*, **longitudinal** in *Euglena* and *Vorticella*, **oblique** in dinoflagellates a **transverse** in *Paramecium* and *Planaria* (= *Dugesia*). In unicellular forms, binary fission is accomplish through mitotic nuclear division followed by cytokinesis. In multicellular individuals like *Plana* (= *Dugesia*) the posterior part is fixed firmly to substratum while anterior part extends forward a exerts a pull causing the middle part to break. (*ii*) **Multiple Fission.** It is formation of a numbe

small daughters by division of a parent. In unicellular forms, the nucleus divides a few times followed by collection of cytoplasm around each daughter nucleus forming a number of daughter cells, *e.g.*, *Amoeba*, *Plasmodium*, *Monocystis*. In *Amoeba*, multiple fission is preceded by **encystment** or cyst formation. It is followed by sporulation in which a number of small **amoebae** (= amoebules) called **pseudopodiospores** are formed. (*iii*) **Plasmotomy.** Cleavage of plasmodium or multinucleate body into multinucleate parts, *e.g.*, *Opalina*, *Pelomyxa*. (*iv*) **Strobilation.** A modification of multiple fission is **strobilation** in multicellular animals (body segmentation for reproduction as forming zooids in coelenterates like *Aurelia* and proglottides in Tapeworm).

2. Spores (Sporulation). Spores are minute single-celled thin-walled propagules which have dual function of dispersal and formation of new individuals. Sporulation or spore formation is common in members of monera, protista, fungi and algae. Motile spores are called **zoospores.** They occur in aquatic organisms, *e.g.*, *Chlamydomonas*, *Ulothrix*. The non-motile spores are named variously, *e.g.*, aplanospores, hypnospores, akinetes, conidia, etc. Some spores are produced exogenously (*e.g.*, conidia in *Penicillium*) while others are formed inside sporangia (*e.g.*, sporangiospores in *Rhizopus*).

In lower organisms, spores are formed both during asexual reproduction as well as after sexual reproduction. Asexual spores are also called **mitopores** as they are produced due to mitotic division of the parent cell. They are also called **accessory spores.** Asexual spores carry the same genome number as that of parent cell, *e.g.*, conidia. Spores formed after sexual reproduction are generally preceded by meiotic division of zygote. They are, therefore, called **meiospores,** *e.g.*, ascospores.

3. Budding. It is a mode of asexual reproduction in which new organisms develop as outgrowth or buds from a parent. (*i*) **Exogenous/External Budding.** The bud develops externally on the parent. In the young condition the two are internally connected to provide nourishment to the bud. Later on, the bud enlarges and becomes nutritionally independent. It then separates as a new individual, *e.g.*, Yeast *Hydra*. However, in some cases, the new individual remains joined to the parent to form **colony,** *e.g.* *Obelia*, *Spongilla*, *Scypha* (= *Sycon*). The individuals present in a colony are called **zooids**. There may be two or more types of zooids in the colony, *e.g.*, *Obelia*. (*ii*) **Endogenous/Internal Budding.** Internal buds or **gemmules/statoblasts** occur in most fresh water sponges/bryozoans to help in dispersal as well as perennation.

4. Fragmentation. There is breakage of the individual into two or more parts called fragments. Fragmentation occurs due to external (*e.g.*, Sea Star) or internal forces (*e.g*, tunicates) like mechanical disturbance, biting of animals, emptying of intercalary cells, decay of older parts, change in environment etc. The fragments grow into independent individuals, *e.g.*, *Marchantia*, *Spirogyra*, *Nostoc*. The phenomenon of growth from fragment is also called **regeneration.**

• Vegetative Reproduction

Vegetative reproduction is the formation of new plants from detached vegetative parts or propagule of the parent.

Vegetative Propagation in Lower Plants. (*i*) **Binary Fission.** A mature unicell divides into two daughters *e.g.*, bacteria, diatoms, *Euglena*. (*ii*) **Budding.** A small outgrowth of the cell that grows and separates, *e.g.*, Yeast. (*iii*) **Fragmentation.** Mechanical disturbance, emptying of intercalary cells decay of older parts, change in environment, etc. cause breakage of the plant body into two or more parts, each of which behaves as independent plant, *e.g.*, *Marchantia*, *Spirogyra*, *Nostoc*. (*iv*) **Gemmae** Gemmae are small undifferentiated multicellular green propagules which separate and form new plants, *e.g.*, *Marchantia*, *Funaria*. (*v*) **Resting Buds.** They are perennating fleshy buds, *e.g.*, *Selaginella subdiaphana* (*vi*) **Tubers.** Underground perennating structures, *e.g.*, *Selaginella chrysocaulos*, *Marsilea* mosses.

Natural Vegetative Propagation in Higher Plants. Here a portion or fragment of the mother plant functions as a propagule to form an independent plant under suitable conditions. Natural modes of vegetative propagation in higher plants are : (*i*) **Roots.** Tap root branches can develop adventitious buds and form new plants in Guava, Poplar (*Populus*) and *Dalbergia*. Fleshy adventitious roots also take part in vegetative propagation in Sweet Potato, *Dahlia* and *Asparagus*. (*ii*) **Underground Stems** (*a*) Stem tubers develop new plants in the region of eyes, *e.g.*, Potato, Artichoke, (*b*) Buds present inside bulbs sprout to form new plants in Onion, Garlic and *Narcissus* (*c*) Corms bear buds for growth of daughter plants, *e.g.*, *Crocus*, *Colocasia*, *Amorphophallus*, *Freesia*. (*d*) Rhizomes take part in vegetative propagation due to presence of buds, *e.g.*, Ginger, Turmeric, Banana (also suckers), ferns. (*e*) Breaking of suckers forms independent plants in Mint and *Chrysanthemum*. Suckers with similar function also occur in Pineapple and Banana. (*iii*) **Subaerial Stems** (Creeping Stems). Runners, stolons and offsets are meant for forming new crowns at their tips as well as nodes in case of the former two. Breakage of these horizontal stems converts the different crowns into independent plants

(offsets), Grass (runners), Strawberry (stolons). (*iv*) **Aerial Shoots.** Segments of *Opuntia and other* cacti produce new plants after falling on ground. (*v*) **Leaves.** Injured leaf of *Begonia* develops new plants in contact with soil while uninjured fallen *Bryophyllum* and *Kalanchoe* leaf does so from buds present in its marginal notches. In *Bryophyllum daigremontianum* marginal buds form plantlets while attached to plants. Leaves also help in vegetative propagation in *Adianum caudatum* (Walking Fern). (*vi*) **Bulbils.** They are fleshy buds which on falling down produce new plants, *e.g.*, *Oxalis*, *Agave*, *Dioscorea*, Lily, etc. In *Dioscorea* (Yam) the bulbils develop in axils of leaves. In *Oxalis* they occur above the base of fleshy root.

• **Horticultural or Artificial Methods of Vegetative Propagation**

1. Use of Special Vegetative Organs. Many plants are multiplied vegetatively by using their specialised vegetative structures like root tubers (*e.g.*, Sweet Potato, Dahlia), corm (*e.g.*, *Crocus*, *Colocasia*, *Gladiolus*), bulb (*e.g.*, Garlic, Onion), part of rhizome (*e.g.*, Banana, Ginger) and stem tuber (*e.g.*, Potato), bulbil (*e.g.*, Pineapple).

2. Cuttings. *Sansevieria* is propagated by leaf cuttings. Root cuttings are used in case of Blackberry, Raspberry, Tamarind and Lemon. Stem cuttings (20-30 cm segments of one year old stem) are employed in case of *Rosa, Clerodendron, Duranta, Citrus, Bougainvillea*, Tea, Coffee and Cocoa. Rooting of stem cuttings is hastened by dipping in NAA or IBA.

3. Layering. The middle part of a soft basal branch is defoliated, slightly injured (tongueing, notching, ringing) and pegged in the soil to develop adventitious roots. Later on the branch or layer is separated and planted, *e.g.*, Cherry, Jasmine, Grape Vine. In **serpentine layering** the branch is pegged at several places so as to form many plants. In **mound layering** the shoot is pruned and lower part covered by soil when a number of new shoots develop, *e.g.*, Gooseberry, Currant. In **air layering** (gootee) a 3·5 cm ring of bark is removed from near the base of an aerial shoot. It is covered by a thick plaster of grafting clay (hay, cowdung, clay, water) with small quantity of root promoting hormone and wrapped in polythene. After 2–3 months, roots appear and the shoot is removed below the bandaged region to be used for planting, *e.g.*, Litchi, Pomegranate, Gauava, Orange, Lemon.

4. Grafting. Cambium bearing shoot (= **scion** = graft) of one plant is joined to cambium bearing stump (root system = **stock**) of a related plant through different unions like tongue grafting (= whip or slice grafting), wedge grafting, crown grafting, side grafting. In crown grafting several scions are joined to a single stock. In approach grafting the shoots of two independently growing plants are brought together, removed off a slice of bark and wood for distance of 2·5 – 5·0 cm or given tongue-like cuts before being bound together by grafting wax. After union, the stock is cut above the graft while scion plant is cut below the graft. Grafting is used for quick multiplication and proper growth of better varieties with weak roots, *e.g.*, Mango, Apple, Pear, Rubber, Orange, etc. In **bud grafting,** the scion is a bud with a small piece of bark, *e.g.*, Rose, Apple, Peach.

5. Micropropagation. Micropropagation is the raising of new plants from a small plant tissue with the help of tissue culture technique. **Tissue culture** is the technique of maintaining and growing cells, tissues, etc. and their differentiation on artificial medium under aseptic conditions inside suitable containers.

Tissue culture technique was first thought of by Haberlandt (1902) and Hanning (1904). Fir successful attempt was made by White (1932) in case of Tomato root who also developed the technic of subculturing and growth of callus. **Callus** is irregular, unorganised and undifferentiated mas actively dividing cells. Darkness stimulates callus formation. Skoog and Miller (1957) found differentiation of callus or morphogenesis is under control of two hormones, auxin (favours root forma and cytokinin (favours shoot formation). Somatic embryos or embryoids were raised by Steward (1 Helperin and Wetherell (1964). **Embryoids** are non-zygotic or somatic embryo-like structures are produced *in vitro* cultures and have the ability to form full fledged plants. Steward (1964) the concept of cellular totipotency. **Cellular totipotency** is the ability of a somatic cell to prod complete organism. The entire vegetatively produced descendants of a single organism are coll called **clone.** An individual member of a clone is called **ramet**. Guha and Maheshwari (1964) d haploid culture or pollen grain culture. Barski *et al* (1960) performed **protoplast fusion** ir while Carlson *et al* (1972) perfected the technique for plants.

The plant part used in culture is known as **explant.** The culture medium may be liquid or solid. The latter two have agar or gelatine. Nutrient medium contains minerals, vitam sucrose, amino acid glycine and growth regulators (or banana pulp/coconut milk/yea Containers, nutrient medium and instruments are autoclaved (at 120°C) for 15 – 30 minu is disinfected with methiolate, clorax water or dilute hypochlorite. Inoculation is carried out area or inoculation chamber disinfected with ultra-violet rays.

• **Culture Experiments**

Steward *et al* (1957) took small piece of tissue from phloem region and placed it in liquid culture medium. The containers were rotated. It gave rise to small cellular aggregates and single cells. On stoppage of shaking, they grew into cellular clumps. The latter formed plantlets on transfer to solid medium.

Muir *et al* (1958) grew single cells over a nurse tissue (callus) with a wet filter paper in between. The single cell formed a cellular clump which on transfer to a new medium formed plantlet. Vasil and Hilderbrandt (1965) grew single cell in a microchamber and got a full fledged plant.

Shoot Tip Culture. Apical meristem with one or two young leaves is removed, sterilised and reared in culture to obtain virus free plants.

Multiple Shoot Culture. Shoot tip with 1 – 4 leaf primordia is sterilised and placed on a culture medium having NAA and high salt content. At intervals of 4 – 6 weeks the shoot tip is given cuts and subcultured. The tissue is transferred to medium with low salt and no NAA for obtaining plantlet. The technique is useful in obtaining a number of pathogen free copies of rare or sterile plant.

Embryo Culture. It is useful in growing plants from dormant seeds. Their embryos are removed and allowed to grow on culture medium. **Embryo rescue** is also performed in case of difficult hybrids.

Somatic Embryogenesis (Embryoid Culture). Separated cells from callus raised from embryo divide and pass through globular, cordate and torpedo like stages as found in an embryo. They are embryoids. Medium rich in ammonium salts with little auxin favour embryoid formation. Each embryoid grows to produce a new plant.

Haploid or Pollen Grain Culture. Young anthers of sterilised unopened floral buds are removed and dropped over culture medium. A number of haploid embryoids are formed after 4–6 weeks. Each such embryoid can form a haploid plant. Application of colchicine to young embryoid forms completely homozygous diploid plant.

Protoplast Fusion. Tissues of two different plants are cultured. Their cells are separated and treated with pectinase as well as cellulase. It produces naked protoplasts. Naked protoplasts of the two types are made to fuse by electrofusion or polyethylene glycol (PEG). Fused protoplast forms **somatic hybrid cells** which on further growth give rise to hybrid plantlets.

• **Somaclonal Variations**

They are tissue culture variations produced in plants. Some of them are stable and useful, *e.g.*, short duration Sugarcane, high protein content of Potato, leaf hopper and tungro virus resistance in Rice.

• **Sexual Reproduction**

It is a mode of multiplication in which the new individuals or young ones are formed through the process of formation and fusion of gametes. Haploid (gametes)–diploid (individual) alternation occurs. Gametogenesis involves meiosis. Fusion of gametes or fertilization restores the chromosome number. The offspring is produced by growth of the fusion product of gametes called zygote. Sexual reproduction is commonly **biparental** with the exception of lower animals and most plants where two types of reproductive organs occur over the same individual. A number of variations appear in the offspring.

• **Origin of Sex**

Sex originated in primitive protistans and simple algae through conversion of asexual spores during unfavourable periods into gametes which fused in pairs and got invigorated. It is called **hunger theory of sex.**

• **Gametes**

The fusing gametes are similar, **isogametes** or **homogametes** in primitive forms, *e.g.*, *Ulothrix*. The phenomenon of their fusion is called **isogamy.** In *Spirogyra*, the gametes are structurally similar but physiologically different. Their fusion is called **physiological anisogamy.** In *Chlamydomonas braunii* the fusing gametes show differences in size and behaviour. It is **anisogamy.** In most plants, there is a non-motile large **egg** or **ovum** and a small active **sperm** or **antherozoid.** Their fusion is called **oogamy.** The term **heterogamety** is used for both anisogamy and oogamy.

• Sexuality in Organisms

In most primitive sexually reproducing organisms, the functional gametes belong to the same or single parent. There is no morphological or physiological difference. These organisms are called **homothallic**, *e.g.*, *Mucor mucedo*. The functional gametes belong to genetically different parents in *Rhizopus stolonifer*, though there is no morphological or physiological difference. Such organisms are

called **heterothallic.** In higher organisms, sex organs developed and got differentiated into male and female. In most flowering plants, both the types of sex organs (stamens and carpels) occur in the same flower. They are called **hermaphrodite** or **bisexual.** In some flowering plants, there are distinct male or **staminate** flowers and female or **pistillate** flowers. In *Cycas* (a gymnosperm), *Vallisneria,* Date Palm and Papaya (angiosperms) the male and female flowers are borne on different plants. They are called **dioecius plants.** Cucurbits, Coconut and Maize possess both male and female flowers on the same plants. They are called **monoecious plants.** The condition of monoecious and dioecious nature is also found in lower plants. *Chara* often bears both male (antheridium) and female (oogonium) sex organs on the same plant. It is, therefore, monoecious. *Marchantia,* a liverwort, is dioecius. Here, the male plant bears antheridia over a special structure called **antheridiophore.** The female plant similarly possesses archegonia over a special structure known as **archegoniophore.**

In animals, **unisexuality** is common so that **cross fertilization** (= **exogamy**) occurs. In some bisexual (monoecious) animals, **self fertilization** (= **endogamy**) or fusion of gametes of the same parent occurs, *e.g., Taenia, Fasciola.* However, cross fertilization is preferred by many of the bisexual animals, *e.g.,* Earthworm.

• Phases in Life Cycle

Three– juvenile, reproductive and senescent (*i*) **Juvenile** or pre-reproductive or vegetative **phase** may have different morphology like shape of leaves and their arrangement. (*ii*) **Reproductive phase** shows slow down of growth. These is development of sex organs like flowers. In **monocarpic plants** flowering occurs only once after which they bear fruits, undergo senescence and die. They may be **annual** (*e.g.,* wheat, *Rice*), **biennial** (*e.g.,* Henbane) or **perennial** (*e.g.,* Bamboos, *strobilanthes.* Bamboos flower after 48 – 100 years, *e.g., Bambusa tulda. Strobilanthes Kunthiana* flowers in 12th year (last in Sep-Oct 2006). **Polycarpic plants** are perennial plants which after reaching sexual maturity flower every year. **Recovery phase** occurs in between two flowering seasons.

• Neoteny and Paedogenesis

Retention of larval characters even in the sexually mature individual or development of adult characters by a larval form is called **neoteny** (Gk. *neos*–young, *temein*–to stretch), *e.g.,* **axolotl** larva of Salamander *Ambystoma,* **Paedogenesis** (Gk. *pais*–child, *genesis*–descent) is reproduction in the young or larval stage, *e.g.*, axolotl.

• Animal Breeding

On the basis of periodicity of breeding, animals are of two types, seasonal and continuous breeders. **Seasonal breeders** reproduce at particular period of the year *e.g.,* frog, lizards, most birds, deer. **Continuous breeders** continue to breed throughout their span of sexual maturity, *e.g.,* cattle, poultry, mice, rabbit, honey bee queen. Birds are commonly seasonal breeders. However, in captivity some of them have become continuous breeders, *e.g.,* poultry birds. In poultry farms, hens continue to lay unfertilised or vegetative eggs throughout the year. It is a commercial exploitation of faculty of reproduction for human welfare.

Ovulation occurs by two methods, spontaneous and induced. **Spontaneous ovulators** are those animals in which the females have a continuous cycling of reproductive hormones and ovulation *e.g.,* humans. **Induced ovulators** are those animals in which ovulation is induced by coitus, *e.g.,* Camel. **Reflex ovulators** ovulate in response to vaginocervical stimulation caused by mating.

In placental mammals, the females show cyclic changes in the activities of ovaries, accessory ducts and hormones throughout their reproductive phase. There are two types of cycles, menstrual and oestrus.

Menstrual Cycle. It is a series of cyclic changes that occur in ovaries, reproductive tract and hormone secretions of female primates (monkeys, apes and humans) from puberty to menopause. There is a regular sloughing off of inner lining of reproductive tract which is passed alongwith some blood as menstruation. An excessive sex urge is absent in any part of menstrual cycle. The periodicity of cycle is a lunar month.

Oestrus Cycle (= Estrus Cycle). It is a series of cyclic changes that are found in the ovaries, reproductive tract and hormones of female non-primate mammals, *e.g.,* cows, dogs, cats, horse, buffalo. There is period called oestrus (= estrus, Gk *oistros* – maddening desire) when the female has a very high blood titre of oestrogens and develops a strong sex heat. During this period the female receives the male. Oestrus lasts for 18 hours in Cow, about a week in dog and cat. At the end of oestrus, a luteal phase or **metoestrus** begins. Then the lining of reproductive tract is shoughed off. However, there is no menstruation. The sloughed off tissues are absorbed. It is followed by a passive period called **anoestrus.** It may vary from a few months to more than a year. Deer is called monoestrus because it experiences oestrus once a year. Dogs are **bioestrus** as they experience two oestruses in a year. Mouse

is polyoestrus (many oestruses in a year). Deer and dogs are seasonal breeders as they develop the urge for sexual reproduction only during particular favourable periods. Mouse is a continuous breeder as it remains reproductively active throughout the year.

• Meiosis

In all sexually reproducing organisms, life cycle possesses two stages, diploid ($2n$) and haploid ($1n$). Gametes are always haploid. The fusion product of two gametes is always diploid. Meiosis occurs in some stage of the life cycle. Depending upon the stage at which it occurs, meiosis is of three types— zygotic, sporic and gametic. The cells which undergo meiosis are called **meiocytes.** They are always diploid.

Chromosome Number in Meiocytes (diploid, 2N) and Gametes (haploid, N) of some Organisms

S. No.	Name of Organism	Meiocyte (2N)	Gamete (N)
1.	Humans	46	23
2.	Housefly	12	6
3.	Rat	42	21
4.	Dog	78	39
5.	Cat	38	19
6.	Fruitfly	8	4
7.	Ophioglossum (a fern)	1260	630
8.	Apple	34	17
9.	Rice	24	12
10.	Maize	20	10
11.	Potato	48	24
12.	Butterfly	380	190
13.	Onion	16	8

• Gamete Transfer

It is the bringing of compatible gametes near each other. Aquatic organisms shed their gametes in water. In case of isogametes as found in some algae and fungi, both the types of gametes are motile and attract each other. In case of heterogametes, there are stationary non-motile female gametes and motile male gametes. In bryophytes and pteridophytes ova occur inside archegonia. The sperms are motile. They require a thin film of water to swim upto open archegonia where an attractant is being released. However, a number of male gametes fail to reach the ova. Therefore, the number of male gametes is always very high as compared to female gametes. For a single ovum in humans, the number of male gametes is 100–400 millions.

In flowering plants, pollen grains carry the male gametes. They are formed in large number. They are transferred to stigma of the female organ or carpel through the process of **pollination.** Pollination precedes fertilization. It is of two types, self pollination and cross pollination. In **self pollination,** the pollen grains of an anther are transferred to the stigma of the same bisexual flower. It occurs through mechanical movement in the bud condition of Pea and Wheat. In **cross pollination,** that occurs in both bisexual and unisexual flowers, the pollen grains are carried to the stigma of other flowers through the agency of wind, water or insects. Pollen grains germinate over the stigma and produce pollen tubes. Pollen tubes carry the male gametes to the ovules and burst open to release male gametes near the female gamete or egg.

Most animals are dioecious or unisexual. They perform cross fertilization (exogamy) or union of gametes belonging to different parents (biparental). In aquatic habitats, they commonly shed the gametes nearby to increase the chances of fusion. In terrestrial habitats, the animals have evolved various techniques for gamete transfer. Even many monoecious or bisexual animals prefer cross fertilization (exogamy) and have developed mechanism for gamete transfer. **Self fertilization** (endogamy) is the fusion of gametes belonging to the same parent (uniparental). In *Taenia*, where self fertilization or **endogamy** occurs, male gametes are transferred from one proglottis to another. Successful transfer and coming together of the two types of gametes is essential for fertilisation.

• Fertilisation

Events leading to coming together and fusion of two compatible gametes to form diploid zygote called **fertilization.** The process of fusion of gametes is called syngamy (Gk. syn, together, gam

marriage). The two terms of syngamy and fertilization are, however, often used interchangeably. Depending upon the place of syngamy; fertilization is of two types, external and internal.

External Fertilization. It is syngamy that occurs outside the body of the organisms. It usually takes place in aquatic medium. External fertilization is common in most algae, some fungi, several invertebrates, bony fishes and amphibians. The organisms performing external fertilization show great syncrony in the release of gametes into the external medium for enhancing the chances of syngamy. Since it involves a chance factor, the number of gametes of both the types is generally large. As a result, the number of offspring is also very high. They are, however, extremely vulnerable to predators for their survival upto adulthood.

Internal Fertilization. It is syngamy or fertilization that occurs inside the body of the organisms. It is common in terrestrial organisms but some aquatic and semiaquatic organisms also perform internal fertilization, *e.g.*, fungi, reptiles, birds, mammals, sharks (cartilaginons fishes), bryophytes, pteridophytes, gymnosperms and angiosperms. Egg remains in the body of the female. The male gamete reaches there to fertilize the same. In animals and seedless embryophytes, the male gametes are motile. They swim up to the female gamete to fertilize it. In seed plants, the male gametes motile. They are carried to the female gamete by means of pollen tube. Since internal fertilization is a sure method, the number of female gametes and hence the number of offspring remains small.

• Embryogenesis

Embryogenesis (*Gk. embryon*–embryo, *genesis*–descent) is the process of development of embryo from zygote. The term **blastogenesis** is used for development of new individuals from buds, fragments and other asexual propagules. **Embryo** is a multicellular stage in the life cycle of a plant or animal prior to formation of an independent individual. In embryogenesis, the zygote undergoes repeated cell divisions through mitosis. The divisions help in growth of the embryo. Cells undergo differentiation attaining specific shape, size and function. Cell differentiation occurs at specific locations resulting in production of different tissues, organs and organ systems. Development of different external and internal structures is called **morphogenesis.**

• Ovipary and Vivipary

On the basis of site of development of embryo, animals are of three types – oviparous, ovoviviparous and viviparous. (*i*) **Ovipary** (Oviparous Animals). Embryo develops inside egg kept outside the body of the female, *e.g.*, Frog, reptiles, birds, most fishes, prototherian mammals. (*ii*) **Ovovivipary** (Ovoviviparous Animals). Development of embryo occurs inside the egg retained by the female without providing any extra nourishment, *e.g.*, sharks, Rattle Snake. (*iii*) **Vivipary** (Viviparous Animals). Embryo develops inside the womb of the female with which it gets connected by placenta for continuous nourishment. The female gives birth to young ones, *e.g.*, human beings.

• Seed and Fruit Formation

In flowering plants, zygote develops into **embryo.** The food for development of embryo comes from a special tissue known as endosperm. Endosperm receives food from nucellus and the plant. Ultimately, the fertilized ovule matures into a **seed.** A number of seeds develop in an ovary depending upon the number of ovules. Meanwhile wall of the ovary also proliferates. It produces **pericarp.** The pericarp can be dry or fleshy. The ripened ovary with pericarp and seeds is called **fruit.** As the fruit begins to develop, sepals petals, stamens, style and stigma are shed. Sepals persist in some cases, e.g., Pea, *Withania.* The fruit is meant for protecting the young seeds. In many cases, it helps in dispersal of the mature seeds. After dispersal, the seeds which reach suitable substratum germinate and form new plants.

• Parthenogenesis (Apomixis)

It is the development of a new individual from a single gamete (generally the egg/ovum) without involving fertilization. Parthenogenesis was discovered by Bonnet (1745) when he found aphid egg to develop into insect without fertilisation. The term was coined by Owen (1848). On the basis of chromosome sets, parthenogenesis is of two types : (*i*) **Arrhenotoky** (Male or Haploid Parthenogenesis). Haploid eggs grow to form haploid males, *e.g.*, arachnids, some insects. (*ii*) **Thelytoky** (Female or Diploid Parthenogenesis). Diploid eggs grow without fertilization into diploid individuals, generally females *e.g.*, Gall Fly. Typhlina. **Diploid arrhenotoky** (diploid males from unfertilised eggs) is known only i scale insect *Lecanium putnami*. Parthenogenesis can be natural or artificial. Natural parthenogenes may be obligatory or cyclic.

Obligatory/Complete Parthenogenesis. Males are absent. Females develop parthenogenetic *e.g.*, rotifers, *Typhlina brahmina* (small lizard, 15 cm long), *Lacerta saxicola-armeniaca* (Cauc Rock Lizard), *Cnemidophorus* (Whiptail Lizards of America).

Cyclic/Incomplete Parthenogenesis. Both ,sexual and parthenogenetic individuals occur. In aphids several generations of parthenogenetic females develop followed by formation of both males and females to perform sexual reproduction. In Turkey, 40% of the males develop parthenogenetically from eggs alone through diploidisation. In Honey Bee, male or drone develops parthenogenetically (no meiosis at the time of spermatogenesis) while queen and workers develop from fertilised eggs. Also in wasps and ants. In Gall Fly, larvae may lay eggs that develop parthenogenetically (**paedogenesis**).

Artificial/Induced Parthenogenesis. Sugar, salt, alkaloids and other chemicals, heat, cold, pricking and other stimuli can stimulate eggs to undergo cleavage and form parthenogenetic embryos. Pincus (1936) was able to induce parthenogenesis in Rabbit eggs by temperature change and chemical agents. Being haploid, they generally do not survive.

AG At a Glance

1. ***Panmictic.*** Plant reproducing asexually.
2. ***Apomictic.*** Plant multiplying parthenogenetically.
3. ***Amphimictic.*** Plant reproducing sexually.
4. ***Time for Horticultural Propagation.*** Rainy season and spring season.
5. ***Grafting and Monocots.*** Grafting is not possible in case of monocots because they do not have cambium/lateral meristem.
6. ***Parthenocarpy.*** It is useless in case of plants where seeds provide the economic produce *e.g.*, Almond, Walnut, Coconut, Pomegranate.
7. ***Wrinkler*** (1908, 1934). Introduced the term apomixis.
8. ***Side Grafting.*** The scion has a smaller diameter than stock.
9. ***Graft Hybrid.*** A **chimera shoot** formed by an adventitious bud formed at the junction of stock and scion. First reported in 1644 as **bizzaria orange** (half orange half citron) in Italy.
10. ***Axenic Culture.*** Pure culture or culture without any contamination.
11. ***Callus.*** Darkness favours callus formation. Callus differs from cancer in retaining the ability to differentiate.
12. ***Culture Nutrients.*** In tissue culture, nutrients are added to the medium as the cells are mostly non-green.
13. ***Embryoids.*** Non-zygotic, **somatic embryo-like** structures formed *in vitro* culture. They were first studied by Steward (1963).
14. ***Somatic/Parasexual Hybridisation/Protoplast fusion.*** First reported by Harrie and Matkins.
15. ***Cellular Totipotency.*** The concept was given by Steward (1964).
16. ***Skoog and Miller*** (1957). Morphogenesis or differentiation in callus depends upon auxin and cytokinin.
17. ***White*** (1932). First to perform tissue culture successfully. However, embryo culture had already been carried out by Laibach (1928) and Hanning (1904).
18. ***Gynogenic Haploids.*** Possible from unpollinated ovules.
19. ***Resistance.*** Resistance to drought, flooding, high salinity, metal ion toxicity or herbicide can be achieved by progressively increasing the stress condition in the tissue culture.
20. ***Synthetic Seed.*** Somatic embryo encapsulated inside a coating like water gel.
21. ***Biotransformation/Culture Products.*** A plant product can be more easily obtained from tissue culture, *e.g.*, shikonin (*Lithospermum erythrorhizon*), taxol (*Taxus brevifolia*), digoxin (*Digitalis lanata*), ajmnalicin (*Catharanthus roseus*).
22. ***Androgenesis.*** Development in which embryo has only paternal chromosomes, male parthenogenesis.
23. ***Gynogenesis.*** Development in which embryo has only maternal chromosomes, female parthenogenesis.
24. ***Richard Owen*** (1848). Studied parthenogenesis in unfertilized egg.
25. ***Charles Bonnet.*** Studied natural parthenogenesis and coined the term parthenogenesis. Mechanical and chemical stumuli were used by Jacques Loeb for **artificial parthenogenesis.**
26. ***Spontaneous Ovulator.*** Ovulation without any external induction.
27. *(i)* ***Induced Ovulator.*** Ovulation after copulation, *e.g.*, Rabbit.
    (ii) ***Reflex Ovulator.*** Ovulation occurs on a stimulation during copulation.
28. ***Animal Cloning.*** First performed by Wilmut and Campbell (1997). The first cloned animal was sheep Dolly (Feb. 13, 1997). Egg cell was taken out when maturation promoting factors (MPF) were at maximum. It was denucleated. A nucleus from udder cell arrested in non-dividing growth phase (Go) by serum starvation was inserted in the denucleated egg. The egg was now allowed to grow naturally.
29. ***Vegetative Apomixis.*** Asexual reproduction in plants by vegetative propagules.

MCQ MUL

1. Apomixis
(A) Deve
(B) Deve gam
(C) Inal
(D) Eff
2. Amphi obtair
(A) A
(B) A
(C)
(D)
3. Pa ind
(A
(I
4.

MCQ MULTIPLE CHOICE QUESTIONS

1. Apomixis is
   (A) Development of plants in darkness
   (B) Development of plants without fusion of gametes
   (C) Inability to perceive stimulus for flowering
   (D) Effect of low temperature on plant growth.
2. Amphimixis is development of an organism obtained through
   (A) Apospory
   (B) Apogamy
   (C) Fusion of gametes
   (D) Without fusion of gametes.
3. Parthenogenesis is development of new individual from
   (A) A single gamete without fertilization
   (B) Fertilization of female gamete with female gamete
   (C) Fertilization of male gamete with male gamete
   (D) Vegetative structure.
4. Reproduction which does not involve gametic union is
   (A) Parasexual reproduction
   (B) Apomixis
   (C) Parthenogenesis
   (D) Agamospermy.
5. Vegetative propagation through budding occurs in
   (A) Rose (B) Agave
   (C) Yeast (D) Ginger.
6. Binary fission is a regular mode of multiplication in
   (A) Yeast (B) Bacteria
   (C) *Marchantia* (D) Mosses.
7. A part of root of *Dalbergia* placed in the soil will
   (A) Sprout
   (B) Decay
   (C) Develop underground complex
   (D) Grow depending upon availability of food.
8. Which root will form a new plant
   (A) *Populus* (B) *Dahlia*
   (C) *Azadirachta* (D) Both **A** and **B**.
9. It is more economical to propagate Potato and Artichoke through
   (A) Pieces of tubers (B) Whole tubers
   (C) Seeds (D) Tissue culture.
10. Onion is propagated through its
    (A) Tubers (B) Bulbs
    (C) Seeds (D) Rhizomes.
11. Bulbils are employed for multiplication of
    (A) *Bryophyllum* (B) Crocus
    (C) *Agave* (D) Strawberry.
12. Leaf tips help in vegetative propagation in
    (A) *Begonia*
    (B) *Bryophyllum*
    (C) *Sensevieria*
    (D) *Adiantum caudatum*. (C.P.M.T. 2013)
13. *Bryophyllum diagremontianum* is characterised by the formation of
    (A) Plantlets in leaf notches while attached to plant
    (B) Plantlets from marginal notches when the leaf falls on the ground
    (C) Buds in the marginal notches of leaves
    (D) Plantlets on the leaves in the region of injury.
14. Corm is used as a means of vegetative multiplication in
    (A) Ginger (B) *Gladiolus*
    (C) Banana (D) Pineapple.
15. Banana is multiplied by means of
    (A) Seeds (B) Leaf cuttings
    (C) Rhizome (D) Offsets.
16. Leaf cuttings are used for quick vegetative propagation of
    (A) *Sansevieria* (B) *Jasminum*
    (C) Tea (D) Blackberry.
17. Blackberry is multiplied through
    (A) Stem cuttings (B) Bulbils
    (C) Leaf cuttings (D) Root cuttings.
18. Stem cuttings are often treated with NAA before sowing in order to promote
    (A) Sprouting of buds
    (B) Rooting
    (C) Layering
    (D) Development of adventitious buds.
19. Leaf and stem cuttings are sown
    (A) Vertically with morphological apical end upwards
    (B) Vertically with morphological basal end upwards
    (C) Laterally with morphological upper side upwards
    (D) Laterally with morphological lower side upwards.
20. Air layering is performed in case of
    (A) Jasmine (B) Grape Vine
    (C) Gooseberry (D) Litchi.

21. Many new plants are obtained through
(A) Air layering
(B) Mound layering
(C) Serpentine layering
(D) Both B and C.

22. The stem branch used in layering is
(A) Upper branch
(B) Young branch
(C) Soft basal branch
(D) Hard basal branch.

23. In grafting, scion forms
(A) Shoot system (B) Root system
(C) New plant (D) Hybrid plant.

24. The technique of pegging a branch in soil is called
(A) Grafting
(B) Layering
(C) Cutting
(D) Vegetative propagation.

25. Bud grafting is commonly used in
(A) Litchi (B) Pomegranate
(C) Rose (D) Jasmine.

26. Vegetatively propagated plants
(A) Show adaptive variations
(B) Better fitted in the struggle for existence
(C) Stouter than parents
(D) Clone of their parent.

27. Clone is
(A) Descendants of a single parent
(B) Vegetatively produced descendants of a single parent
(C) Sexually produced descendants of a single couple
(D) All the above

28. Which one is propagated by cuttings
(A) Bougainvillea (B) Tea
(C) Sansevieria (D) All the above.

29. Grafting is employed for better and quicker yield of good varieties of
(A) Apple (B) Citrus
(C) Mango (D) All the above.

30. Parthenogenesis is formation of
(A) Embryo without fertilization
(B) Embryo from pollen sac
(C) Sporophytic plantlet from gametophyte
(D) Fruit without fertilization.

31. The smallest viable unit which can grow, multiply and form a plant in tissue culture is
(A) Chromosome (B) Nucleus
(C) Cell (D) Tissue.

32. Micropropagation is
(A) Raising of plants from a small tissue in culture
(B) Multiplication of small plants
(C) Propagation of small parts of organisms
(D) Indefinite maintenance of an organ or tissue.

33. Tissue culture is
(A) Growth of specific plant structures on artificial medium
(B) Growth and multiplication of cells on artificial medium
(C) Cryogenic maintenance of tissues
(D) Maintenance, growth and differentiation of cells, tissues and organs on artificial medium.

34. Part of plant used for culturing is called
(A) Scion (B) Explant
(C) Stock (D) Callus.

35. Tissue culture technique was first attempted by
(A) Haberlandt (B) Hanning
(C) Nobecourt (D) Gautheret.

36. Tissue culture technique was first performed successfully by
(A) Haberlandt (B) Nobecourt
(C) White (D) Gautheret.

37. The structure employed by White for first successful tissue culture was
(A) Root of Carrot (B) Root of Tomato
(C) Leaf cells (D) Apical meristem.

38. Callus is
(A) Tissue that forms embryo
(B) An insoluble carbohydrate
(C) Tissue that grows to form embryoid
(D) Unorganised actively dividing mass of cells maintained in culture.
(*D.P.M.T. 1996*)

39. Callus formation is promoted by
(A) Proper light and subculturing
(B) Darkness and subculturing
(C) Excess of NAA
(D) Absence of salts.

40. Differentiation of callus into plant parts is
(A) Embryogenesis
(B) Embryoid formation
(C) Morphogenesis
(D) Totipotency.

41. Who discovered that morphogenesis in culture medium is controlled by hormones
(A) Muir *et al*
(B) Vasil and Hilderbrandt
(C) Skoog and Miller
(D) Helperin and Wetherell.

42. Embryoid culture technique was discovered by

(A) Guha and Maheshwari
(B) Skoog and Miller
(C) Muir *et al*
(D) Steward.

43. Embryoid is
(A) A miniature embryo
(B) Non-zygotic embryo formed *in vitro* culture
(C) Embryo raised in culture medium
(D) Cellular aggregate similar to embryo in appearance.

44. The concept of cellular totipotency was given by
(A) Steward
(B) Vasil and Hilderbrandt
(C) Carlson *et al*
(D) Barski *et al*. *(B.H.U. 1996)*

45. Ramet is
(A) Clone (B) Individual of clone
(C) Cell aggregate (D) Callus.

46. Guha and Maheshwari are famous for
(A) Shoot tip culture (B) Protoplast fusion
(C) Embryoid culture (D) Pollen culture.

47. The technique of protoplast fusion was developed by
(A) Helperin and Wetherell
(B) Carlson *et al*
(C) White
(D) Steward.

48. Explant is required to be disinfected before placing in culture. This is done by
(A) Autoclaving
(B) Ultra-violet rays
(C) Clorax or hypochlorite
(D) X-rays.

49. Aseptic culture means
(A) Absence of life
(B) Presence of bacteria
(C) Absence of other organisms like microbes
(D) Parthenogenetic development.

50. Variations appearing suddenly in cultures are
(A) Somatic variations
(B) Somaclonal variations
(C) Mutations
(D) Aberrations.

51. Virus free plants can be obtained through
(A) Shoot tip culture (B) Haploid culture
(C) Protoplast fusion (D) Embryo culture.

52. What additional treatment is required for protoplast fusion in plants
(A) Polyethylene glycol and sodium nitrate
(B) Coconut milk and glycine
(C) Cellulase and pectinase
(D) All the above.

53. Protoplast fusion results in
(A) Parasexual/somatic hybridisation
(B) Genetic hybridisation
(C) Male sterility
(D) Rapid growth and acclimitisation.

54. Pollen culture produces
(A) Haploid plants where every gene can express its effect
(B) Homozygous diploid plants
(C) Abundant seeds of rare plants
(D) Abundant pollen in male sterile plants.

55. An androgenic plant can be converted into homozygous diploid plant through the application of
(A) Nitrogen mustard (B) Nitrous acid
(C) Colchicine (D) Acridine orange.

56. The enzymes required to obtain wall-free/ naked protoplasts are
(A) Cellulase and proteinase
(B) Cellulase and pectinase
(C) Cellulase and amylase
(D) Amylase and pectinase. *(B.H.U. 1996)*

57. Which technique can be helpful in over-coming hybridisation barrier
(A) Shoot tip culture
(B) Embryo rescue
(C) Protoplast fusion
(D) Both B and C.

58. Two protoplasts can be made to fuse through the application of
(A) Electrofusion
(B) Polyethylene glycol
(C) Sodium nitrate
(D) All the above.

59. Who developed the technique of nurse tissue to show cellular totipotency
(A) Hilderbrandt (B) Steward
(C) Muir (D) Konar.

60. Pollen embryoids were discovered by
(A) Konar and Nataraja
(B) Guha and Maheshwari
(C) Skoog and Miller
(D) Helperin and Wetherell.

61. The term parthenogenesis was introduce
(A) Charles Bonnet (B) Karl von Baer
(C) Spallanzani (D) None of the a

62. Endogenous budding occurs in
(A) *Hydra* (B) Marine sp
(C) Fresh water sponge (D) Obelia.

63. Pseudopodiospores are formed in
(A) *Amoeba* (B) Plasmo
(C) *Planaria* (D) Euglen

64. Crocodile lives for about
(A) 10 years (B) 20 years
(C) 40 years (D) 60 years.

65. Binary fission is longitudinal in
(A) *Paramoecium* (B) *Vorticella*
(C) *Amoeba* (D) *Plasmodium*.

66. *Penicillium* produces
(A) Zoospores (B) Mitospores
(C) Meiospores (D) Both B and C.

67. Tapeworm shows
(A) Strobilation (B) Plasmotomy
(C) Multiple fission (D) Binary fission.

68. A dioecious plant is
(A) *Pinus* (B) Maize
(C) *Cycas* (D) *Chara*.

69. The dioecious plant *Marchantia* develops sex organs on
(A) Antheridiophore (B) Archegoniophore
(C) Both A and B (D) Tassel.

70. Dog is a
(A) Continuous breeder (B) Seasonal breeder
(C) Monoestrus (D) Polyoestrus.

71. Fertilization is internal in
(A) Amphibians (B) Star Fishes
(C) Bony Fishes (D) Sharks.

72. Whiptail lizards show
(A) Periodic parthenogenesis
(B) Paedogenic parthenogenesis
(C) Obligatory parthenogenesis
(D) Incomplete parthenogenesis.

73. Thelytoky occurs in
(A) Aphids (B) *Typhlina*
(C) Honey Bee (D) Wasp.

74. Endogamy is reported in
(A) *Fasciola* (B) Earthworm
(C) *Marchantia* (D) Rabbit.

RQ REVISION QUESTIONS FROM COMPETITIVE EXAMS.

75. Apomixis is development of a new plant
(A) Without fusion of gametes
(B) From fusion products of gametes
(C) From stem cuttings
(D) From root cuttings.
(C.P.M.T. 2000, A.I.I.M.S. 1997, B.H.U. 2007)

76. Development of an organism from female gamete/egg without involving fertilization is
(A) Adventitive embryony
(B) Polyembryony
(C) Parthenocarpy
(D) Parthenogenesis.
(A.F.M.C. 1993, B.H.U. 1990, 1998, C.B.S.E. 1989, C.P.M.T. 1986, 1993, 1996, D.P.M.T. 2002, M.P.P.M.T. 2009)

77. An example of parthenogenesis in the development of fruit is the one
(A) With viable seeds after fertilization
(B) With viable seeds after pollination
(C) With viable seeds without fertilisation
(D) Without seeds after pollination.
(Pb. P.M.T. 1992)

78. Scion is the term used in relation to
(A) Embryology (B) Grafting
(C) Agamospermy (D) Emasculation.
(Har. P.M.T. 2001, M.H.T.C.E.T. 2010)

79. Clone is a group of individuals got through
(A) Self pollination
(B) Cross pollination
(C) Vegetative propagation
(D) Hybridisation.
(D.P.M.T. 1997, J.I.P.M.E.R. 1999, A.F.M.C. 1999)

80. Which is not a method of vegetative propagation
(A) Micropropagation (B) Budding
(C) Sowing (D) Layering
(A.F.M.C. 1990)

81. A population of genetically identical individuals, obtained from asexual reproduction is
(A) Callus (B) Clone
(C) Deme (D) Aggregate.
(C.B.S.E. 1993)

82. Parthenogenesis is
(A) Development of embryo without fertilization
(B) Development of fruit without fertilization
(C) Development of fruit without hormones
(D) Development of embryo from egg without fertilization.
(C.B.S.E. 1992, B.H.U. 1996, D.P.M.T. 1997)

83. Cellular totipotency was demonstrated by
(A) Theodore Schwann
(B) A.V. Leeuwenhoek
(C) F.C. Steward
(D) Robert Hooke.
(C.B.S.E. 1991)

84. A totipotent cell means
(A) An undifferentiated cell capable of developing into a system or entire plant
(B) An undifferentiated cell capable of developing into an organ
(C) An undifferentiated cell capable of developing into complete embryo
(D) Cell which lacks the capability to differentiate into an organ or system.
(C.P.M.T. 1995)

85. A major use of embryo culture is in
(A) Induction of somaclonal variations
(B) Overcoming hybridisation barriers
(C) Production of alkaloids
(D) Clonal propagation. (B.H.U. 2000)

86. On culturing the young anther of a plant a botanist got a few diploid plants alongwith haploid plants. Which of the following might have given the diploid plants
(A) Exine of pollen gram
(B) Vegetative cell of pollen
(C) Cells of anther wall
(D) Generative cell of pollen. (B.H.U. 1992)

87. Which ones produce androgenic haploids in anther cultures
(A) Anther wall
(B) Tapetal layer of anther wall
(C) Connective tissue
(D) Young pollen grains.
(C.B.S.E. 1990, D.P.M.T. 1997)

88. In Tobacco callus, which one shall induce shoot differentiation in combination of auxin and cytokinin
(A) Higher concentration of cytokinin and lower concentration of auxin
(B) Lower concentration of cytokinin and higher concentration of auxin
(C) Only cytokinin and no auxin
(D) Only auxin and no cytokinin.
(D.P.M.T. 1986, 1993, 1997, C.B.S.E. 2003)

89. Who could grow Tomato roots successfully and develop the technique of tissue culture for the first time
(A) Hilderbrandt (B) P.R. White
(C) W.H. Muir (D) F.C. Steward.
(J.I.P.M.E.R. 1997)

90.* Which of the following plant cells will show totipotency
(A) Sieve tubes (B) Xylem vessels
(C) Meristem (D) Cork cells.
(C.B.S.E. 1993, C.M.C. 2002)

91. Variations observed during tissue culture of some plants are known as
(A) Clonal variations
(B) Somaclonal variations
(C) Somatic variations
(D) Tissue culture variations. (A.M.U. 1992)

92. Virus free plants can be obtained by
(A) Antibiotic treatment
(B) Bordeaux mixture
(C) Root tip culture
(D) Shoot tip culture.
(M.P.P.M.T. 1992, A.I.I.M.S. 1992, 1996, D.P.M.T. 1997, 1999, Har. P.M.T. 2003)

93. Tissue culture technique can produce indefinite number of new plants from a small parental tissue. The economic importance of the technique is in raising.
(A) Variants through picking up somaclonal variations
(B) Genetically uniform population of an elite species
(C) Homozygous diploid plants
(D) Development of new species.
(A.I.I.M.S. 1992)

94. External water is not required for fertilization of
(A) Pteriodophytes (B) Bryophytes
(C) Thallophytes (D) Spermatophytes.
(B.H.U. 1992, R.P.M.T. 1996)

95. Syngamy means
(A) Fusion of gametes
(B) Fusion of cytoplasms
(C) Fusion of two similar spores
(D) Fusion of two dissimilar spores.
(C.B.S.E. 1991)

96. Estrus cycle is indication of
(A) Breeding period (B) Estrogen secretion
(C) Pregnancy (D) Menopause.
(M.P.P.M.T. 1993)

97. A quicker regeneration of grass leaves shall occur by
(A) Cutting (B) Grazing
(C) Irrigation (D) Clipping.
(M.P.P.M.T. 199

98. Monoestrus animals have
(A) One ovulation each month
(B) One egg
(C) One breeding season in a year
(D) One menses each month.
(M.P.P.M.

99. For ovulation in reflex ovulators
(A) Coitus is necessary
(B) Coitus is not necessary
(C) Plenty of food is not necessar
(D) Plenty of food is necessary.
(M.I

100. Estrous cycle is characteristic of
(A) Human females
(B) Mammalian females
(C) Mammalian females other than primates
(D) Mammals. *(C.B.S.E. 1995, Wardha 2002)*

101. Grafting is not possible in monocots as they
(A) Lack cambium
(B) Are herbacous
(C) Have scattered vascular bundles
(D) Have parallel venation.
(B.H.U. 1995, A.F.M.C. 1999, C.E.T. Chd. 2001, M.H.T.C.E.T. 2009, K.C.E.T. 2009)

102. A piece of Potato tuber will form a new plant if it has
(A) Branches (B) Stored food
(C) Roots (D) Scales/eyes. *(C.P.M.T. 1996)*

103. Layering is used for vegetative propagation of
(A) Rose (B) Jasmine
(C) Mango (D) All the above. *(A.F.M.C. 1996)*

104. Roots are used in vegetative propagation of
(A) Ginger (B) Chrysanthemum
(C) Sweet Potato (D) Potato.
(A.M.U. 1996, J.I.P.M.E.R. 1997, M.H.T.C.E.T. 2008, 2010)

105. Individuals of a clone have
(A) Same age
(B) Same height
(C) Same genome
(D) Same number of leaves. *(B.H.U. 1996)*

106. Asexually produced organism inheriting all the characters of the parent is
(A) Offspring (B) Clone
(C) Variety (D) Hybrid.
(C.E.T. Chd. 1997, H.P.P.M.T. 2010)

107. Stem cuttings are commonly used in propagation of
(A) Mango (B) Cotton
(C) Rose (D) Banana.
(B.H.U. 1998, 2005)

108. Haploid plant cultures are got from
(A) Leaves (B) Root tip
(C) Pollen grain (D) Buds
(C.P.M.T. 1994, C.B.S.E. 1994, M.P.P.M.T. 2000, K.C.E.T. 2002)

109. Somaclonal variations are the ones
(A) Caused by mutagens
(B) Produced during tissue culture
(C) Induced during sexual embryogeny
(D) Caused by gamma rays.
(B.H.U. 1994, D.P.M.T. 1999)

110. Parasexual hydridisation means fusion of
(A) Male gamete with female gamete
(B) Male gamete with synergid
(C) Somatic protoplasts
(D) Male gamete with somatic cell *(M.P.P.M.T. 1995)*

111. Application of embryo culture is in
(A) Clonal propagation
(B) Overcoming hybridisation barrier
(C) Production of alkaloids
(D) Formation of somaclonal variations. *(D.P.M.T. 1993, 1997)*

112. Plants developed *in vitro* culture from pollen grains are
(A) Androgenic haploids
(B) Pollen plants
(C) Male plants
(D) Sterile plants. *(A.I.I.M.S. 1996, A.M.U. 1998, Bih P.M.T. 2001)*

113. In tissue/bacterial culture glassware and nutrients are sterilised through
(A) Water bath at 200°C
(B) Dry air oven at 200°C
(C) Dehumidifier
(D) Autoclave. *(A.I.I.M.S. 1996)*

114. Development of shoot and root in tissue culture is determined by
(A) Cytokinin and auxin ratio
(B) Enzymes
(C) Temperature
(D) Plant nutrients.
(A.I.I.M.S. 1997, D.P.M.T. 1997, B.H.U. 1997, Har. P.M.T. 2000)

115. Plant medium used widely in preparation of culture medium is got from
(A) *Cycas revoluta*
(B) *Cocos nucifera*
(C) *Pinus roxburghii*
(D) *Borassus flabellifera.* *(A.I.I.M.S. 1998)*

116. Mango and Guava are propagated through
(A) Tissue culture (B) Grafting
(C) Stem cuttings (D) Layering.
(Har. P.M.T. 2000)

117. *Chrysanthemum* multiplies vegetatively by
(A) Suckers (B) Runners
(C) Stolons (D) Rhizomes
(E) Bulbils. *(Kerala 2000)*

118. In vegetative propagation by tubers, which o following remains constant throug generations
(A) Morphology
(B) Vigour only

(C) Vigour and morphology only
(D) Morphology, vigour and disease resistance. (*D.P.M.T. 2001*)

119. Induction of rooting on stems before separating them from parent plant is
(A) Grafting (B) Layering
(C) Cutting (D) Root-stem joint
(E) Plant tissue culture. (*Kerala 2001*)

120. Clonal cell lines are got from
(A) Tissue culture
(B) Tissue fractionation
(C) Tissue homogenisation
(D) Tissue system. (*M.P.P.M.T. 2000*)

121. Axenic culture is
(A) Culture of tissue
(B) Culture of genes
(C) Pure culture without contamination
(D) Pure culture of microbe without any external nutrient. (*A.F.M.C. 2000*)

122. A cell from leaf is made to grow into complete plant under culture conditions. It shows cellular
(A) Cloning (B) Totipotency
(C) Hybridisation (D) All the above. (*Wardha 2000*)

123. Out of the following which two methods yield genetically similar plants : (*i*) Stem cuttings (*ii*) Seed production (*iii*) Mutation (*iv*) Tissue culture
(A) (*i*) and (*ii*) (B) (*ii*) and (*iii*)
(C) (*i*) and (*iv*) (D) (*ii*) and (*iv*). (*J.K.C.E.T. 2000*)

124. In tissue culture, callus can be induced to form shoot or root by altering the ratio of
(A) Auxin to cytokinin
(B) Cytokinin to ethylene
(C) Auxin to gibberellin
(D) Gibberellin to cytokinin. (*J.I.P.M.E.R. 2000*)

125. Method of raising new plants in large number from a small plant tissue over a culture medium is
(A) Callus formation
(B) Micropropagation/tissue culture
(C) Micrografting
(D) Juvenility. (*Manipal 2001, Manipur 2009, K.C.E.T. 2010*)

126. First successful animal clone was
(A) Dolly goat (B) Dolly sheep
(C) Molly goat (D) Molly sheep. (*C.B.S.E. 2000*)

127. Hormone used in tissue culture for better growth is
(A) Gibberellin (B) Auxin
(C) Cytokinin (D) Both B and C. (*Har. P.M.T. 2001*)

128. First step in protoplasm fusion is
(A) Collection of somatic cell
(B) Selection and isolation of somatic cells
(C) Isolation of protoplasts
(D) Hybridisation. (*Tamil Nadu 2001*)

129. Potatoes are cultivated by
(A) Seeds (B) Foliar buds
(C) Buds on tubers (D) Cuttings of roots. (*B.H.U. 2002*)

130. Ginger is multiplied vegetatively by
(A) Rhizome (B) Tuber
(C) Stem (D) Bud. (*D.P.M.T. 2002*)

131. *Bryphyllum* is multiplied vegetatively by
(A) Roots (B) Leaves
(C) Stem branch (D) Rhizome
(E) Tuber. (*Kerala 2002*)

132. Development of haploid plants from pollen is
(A) Parthenocarpy
(B) Emasculation
(C) Androgenesis
(D) Somatic hybridisation. (*E.A.M.C.E.T. 2002*)

133. Piece of plant tissue used in tissue culture is
(A) Inoculant (B) Somaclone
(C) Clone (D) Explant. (*Odisha 2002*)

134. Embryoids formed in tissue culture from pollen grain are due to
(A) Test tube culture
(B) Cellular totipotency
(C) Organogenesis
(D) Double fertilisation. (C.B.S.E. 2002)

135. F.C. Steward is associated with
(A) Molecular biology (B) Genetics
(C) Tissue culture (D) Immunology. (D.P.M.T. 20

136. Explant is
(A) A small part of plant for tissue cultu
(B) Exploited part of plant
(C) Harvested plant
(D) Uprooted part for transplantation. (J.K.C.E.

137. Callus is
(A) Material that heals injury in ph
(B) Undifferentiated mass of cells
(C) Tissue developed in the region
(D) All the above. (J.K.

138. Plant propagated by leaves is
(A) *Kalanchoe* (B) Aga

(C) Potato (D) Gladiolus. (D.P.M.T. 2003)

139. Binary fission is a type of
(A) Vegetation propagation
(B) Asexual reproduction
(C) Sexual reproduction
(D) Nuclear fragmentation. (C.P.M.T. 2003)

140. In oogamy fertilisation involves
(A) A small non-motile female gamete and large motile male gamete
(B) A large non-motile female gamete and small motile male gamete
(C) A large non-motile female gamete and a small non-motile male gamete
(D) A large motile female gemete and a small non-motile male gamete.
(C.B.S.E. 2004, Uttarakhand 2014)

141. Maximum life span of a dog in years is
(A) 5 (B) 10
(C) 15 (D) 20. (A.FM.C. 2004)

142. Menstrual cycle occurs in
(A) Female primates
(B) Human females
(C) Mammalian females
(D) Rabbit. (Wardha 2005)

143. Parthenogenesis is connected with
(A) Sexual reproduction
(B) Asexual reproduction
(C) Regeneration
(D) Budding. (Odisha 2005)

144. In which one pair both the plants can be vegetatively propagated by leaf segments ?
(A) *Agave* and *Kalanchoe*
(B) *Bryophyllum* and *Kalanchoe*
(C) *Asparagus* and *Bryophyllum*
(D) *Chrysanthemum* and *Agave*.
(C.B.S.E. 2005)

145. Artificial vegetative reproduction through cutting of roots is carried out in
(A) *Lemon* and *Rose*
(B) *Rose* and *Hibiscus*
(C) *Tamarind* and *Chrysanthemum*
(D) *Lemon* and *Tamarind*. (Guj. C.E.T. 2006)

146. Seedless fruits in Banana are produced through
(A) Asexual reproduction
(B) Parthenogenesis
(C) Triploid
(D) Cross pollination. (Bihar 2006)

147. The internal buds of fresh water sponges are otherwise called
(A) Choanocyte (B) Gemmule
(C) Osculum (D) Blastula
(E) Gastrulla. (Kerala 2006)

148. Which of the following groups of plants are propagated through underground root ?
(A) Bryophyllum and kalanchoe
(B) Ginger, potato, onion and zamikand
(C) Pistia, chrysanthemum and pineapple
(D) Sweet potato, asparagus, tapioca and dahlia
(E) Agave, wild yam and oxalis. (Kerala 2006)

149. Grafting is not successful is monocots but is successful in dicots because they have
(A) Vascular bundles arranged in a ring
(B) Cambium for secondary growth
(C) Vessels with elements arranged end to end
(D) Cork cambium. (A.I.I.M.S. 2006)

150. A scion is grafted on a stock. Quality of fruits produced will depend upon genotype of
(A) Scion (B) Stock
(C) Both **A** and **B** (D) None of the above. (A.I.I.M.S. 2006)

151. Through which technique more female plants can be produced in Papaya
(A) Genetic engineering
(B) Polyploid breeding
(C) Spraying ethephon
(D) Tissue culture. (E.A.M.C.E.T. 2006)

152. Hermaphrodite animal is
(A) Spider (B) Honey Bee
(C) *Ascaris* (D) Leech. (Manipur 2006)

153. Greek word "sexus" means
(A) Disjunction (B) Disintegration
(C) Union (D) Both **A** and **B**. (M.H.T.C.E.T. 2007)

154. During favourable condition the encysted amoeba divides by multiple fission and produces pseudopodiospores. This phenomenon is known as
(A) Budding (B) Sporulation
(C) Fragmentation (D) Regeneration. (H.P.P.M.T. 2007)

155. Transverse binary fission occurs in
(A) *Euglena* (B) *Amoeba*
(C) *Hydra* (D) *Paramecium*. (D.P.M.T 2007

156. Plants with poor root system are propagate through
(A) Layering (B) Leaf cuttings
(C) Stem cuttings (D) Grafting. (M.H.T.C.E.T. 20

157. Type of asexual reproduction found in Hyd is

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