CONCEPT MAP

ASEXUAL REPRODUCTION

Life cannot be created *de novo* rather it arises from pre-existing life. Reproduction is the only method by which continuity of life is maintained. It is of two types: asexual and sexual. Asexual reproduction is the formation of new individual without involving fusion of gametes. It is uniparental as offspring are produced by a single parent.

CHARACTERISTICS OF ASEXUAL REPRODUCTION

- It is more primitive than sexual reproduction as it involves only mitotic divisions.
- New organisms are produced from the somatic part of parental organism, so it is also called as somatogenic reproduction.
- New individuals produced are genetically similar to the parent as well as to each other and are called clones. Hence, it plays no role in evolution.
- Unit of reproduction may be either whole parent body, or a bud, or a body fragment, or a single somatic cell.
- It is usually found in lower organisms like protistan protozoans (*Amoeba, Paramecium*), sponges (*Scypha*), coelenterates, (*Hydra, Tubularia,* etc.), certain flatworms (*Planaria*), some worms and tunicates (*Salpa, Ascidia*, etc.). It is absent in higher invertebrates and all vertebrates.

TYPES OF ASEXUAL REPRODUCTION

Fission

- It is a type of asexual reproduction in which the parent organism divides into two or more daughter cells.
- In this type of reproduction, whole parent body acts as the reproductive unit.
- It is of three types:

(a) Binary fission : In this, parent organism divides into two halves, each half forming an independent daughter organism. It can be simple (occurs through any plane, *e.g., Amoeba*), longitudinal (plane of division is longitudinal axis of body, *e.g., Euglena*), transverse (plane of division runs along transverse axis of body, *e.g., Paramecium*) and oblique (plane of division is oblique, *e.g., Ceratium*).

(b) Multiple fission : In this process, parent body divides into many similar daughter organisms. It occurs during unfavourable conditions. Nucleus of the parent divides by repeated amitosis into many nuclei which eventually form several daughter cells. *E.g., Amoeba, Plasmodium* (malarial parasite).

(c) Plasmotomy-Division of multinucleate parent into many multinucleate daughter individuals without division of nuclei. Nuclear division occurs later to maintain number of nuclei. *E.g., Opalina, Pelomyxa.*

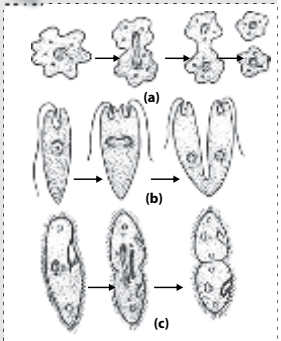


Fig.: Binary fission in (a) *Amoeba* (b) *Euglena* (c) *Paramecium*

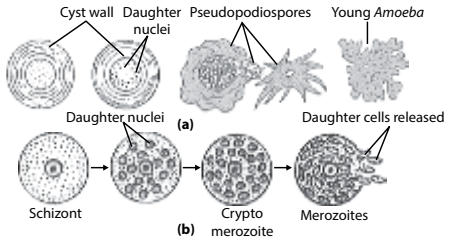


Fig.: Multiple fission (a) *Amoeba* (b) Malarial parasite

Regeneration

- It refers to the growth of new tissues or organs to replace lost or damaged part.
- Regeneration is of two types: **morphallaxis** (formation of whole body from a fragment) and **epimorphosis** (replacement of lost parts). It can be reparative (regeneration of damaged tissue only) or restorative (redevelopment of severed body part). In epimorphosis, a mass of undifferentiated cell referred to as blastema is formed after wound healing and then the blastema cells actively proliferate to restore the lost part of the amputated organ.
- Regeneration is found in *Hydra*, starfish, *Planaria*, etc.

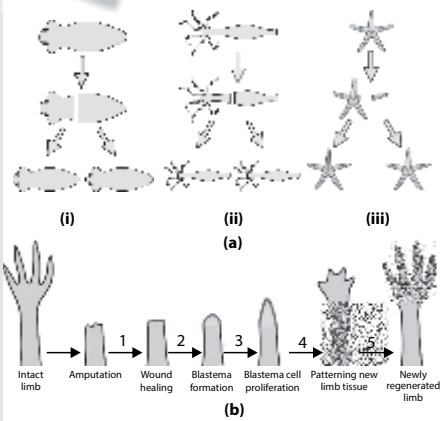


Fig.: (a) Regeneration in (i) *Planaria* (ii) *Hydra* (iii) Starfish (b) Epimorphosis

Budding

- Budding refers to the process of formation of daughter individuals from a small projection or bud arising on the parent body.
- Each bud enlarges, develops parental characters and separates to lead an independent life.
- Budding can be either **exogenous** (formed on the outer surface) *e.g., Hydra,* yeast or **endogenous** (formed inside parent body) *e.g., Spongilla.* In *Spongilla,* bud is called a **gemmule.**

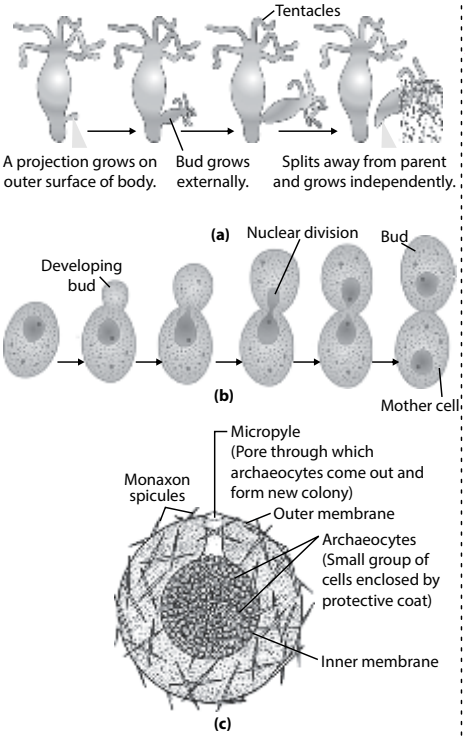


Fig.: (a) Exogenous budding in *Hydra* (b) Exogenous budding in yeast (c) Endogenous budding (gemmule) in *Spongilla*

Fragmentation

- In this type of reproduction, parent body breaks into two or more pieces called fragments.
- Each fragment develops into a new organism.
- In fragmentation, rate of reproduction is high.
- It occurs in flatworms, sea anemones, coelenterates, echinoderms, algae like *Spirogyra*, etc.

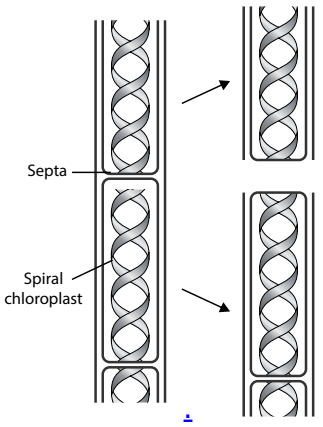


Fig.: Fragmentation in *Spirogyra*

Sporulation

- Spores are minute, single celled, thin or thick walled propagules which are dispersive structures released from the parent body and form new individuals. Spore formation is common in members of monera, protista, algae and fungi. Some of the commonly produced spores are:

(a) Zoospores : Motile and flagellated spores produced inside zoosporangia. Flagella help in proper dispersal in aquatic habitat. *E.g.,* algae and lower fungi like Phycomycetes.

(b) Conidia : Non-motile spores produced singly or in chains by constriction at the tip or lateral side of special hyphal branches called conidiophores. These are dispersed by wind and germinate to form new individuals. *E.g., Penicillium.*

(c) Chlamydospores : Thick walled spores produced directly from hyphal cells. May be terminal or intercalary in position and capable of withstanding unfavourable conditions. *E.g., Rhizopus.*

(d) Oidia : Small fragments of hyphae that are thin walled and do not store reserve food material. Oidia give rise to new hyphae. These are formed under conditions of excess water, sugar and certain salts. *E.g., Agaricus.*

(e) Sporangiospores : Non-motile spores produced inside sporangia. Usually get dispersed by wind and germinate to form new mycelium. *E.g., Rhizopus, Mucor.*

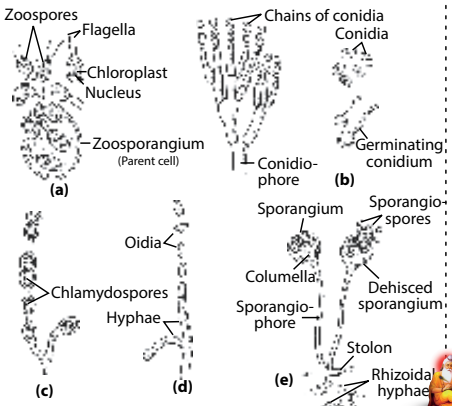


Fig.: Various types of spores (a) Zoospores (b) Conidia (c) Chlamydospores (d) Oidia (e) Sporangiospores

CONCEPT MAP

ASEXUAL REPRODUCTION

Asexual reproduction is the production of offspring from a single parent with or without the involvement of gamete formation. The offspring produced are morphologically and genetically similar to one another and are exact copies of their parents, hence called clones.

FISSION

It is the division of parent body into 2 or more daughter individuals identical to the parent. It is of three types: binary fission, multiple fission and plasmotomy.

Binary fission

The parent organism divides mitotically into two halves, each half forming an independent daughter organism. It is of following types: (i) **Simple binary fission -** division occurs through any plane, *e.g, Amoeba*. (ii) **Longitudinal binary fission -** division passes along the longitudinal axis of an organism, *e.g., Euglena*. (iii) **Transverse binary fission -** division occurs along the transverse axis of the individual, *e.g., Planaria*. (iv) **Oblique binary fission -** division is oblique, *e.g., Ceratium*.

Multiple fission

There is repeated division of the parent body into many daughter organisms, *e.g., Plasmodium*.

Fig.: Multiple fission in *Plasmodium*

Plasmotomy

There is division of a multinucleate parent into many multinucleate daughter individuals without division of nuclei, *e.g., Opalina*.

BUDDING

Daughter individual is formed from a small part or bud, arising from parent body. In animals it is of three types:
(i) **Exogenous budding** : The bud grows externally on the surface of the body. It may split away from the parent *e.g., Hydra* or remain attached to it, *e.g., Sycon*. In yeast, bud is formed on one side of the parent cell and soon it separates and grows into a new individual.
(ii) **Endogenous budding** : The buds are formed within the parent's body. They are called gemmules which consist of small group of cells in a protective covering, *e.g., Spongilla*.
(iii) **Strobilation :** The repeated formation of similar segments by a process of budding is called strobilation. The segmented body is called a **strobila** larva and each segment is called an **ephyra** larva *e.g., Aurelia*.

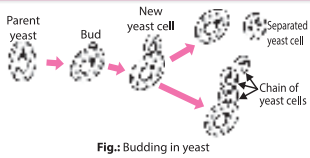


Fig.: Budding in yeast

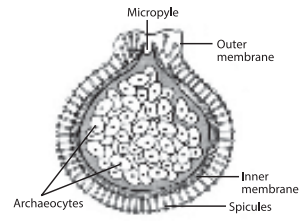


Fig.: Gemmule

GEMMAE

These are unicellular or multicellular propagules which develop in small receptacles called gemma cups. They detach from the parent and grow into new individuals, *e.g., Marchantia*.

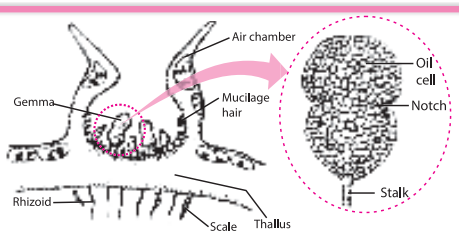


Fig.: Gemma cup of *Marchantia*

FRAGMENTATION

The parent body breaks into two or more pieces called fragments. Each fragment develops into an individual, *e.g., Spirogyra, Rhizopus* etc.

REGENERATION

Regeneration is the regrowth in the injured region. It is of two types: (i) **Morphallaxis** : The whole body is formed from a small fragment, *e.g., Hydra*. (ii) **Epimorphosis** : It is the replacement of lost body part. It can be **reparative** (only certain damaged tissues regenerate) or **restorative** (several body parts can redevelop, *e.g.,* broken tail of wall lizard).

Fig.: Regeneration in *Hydra*

SPORE FORMATION

Spores are microscopic, single-celled, thin or thick walled propagules which develop asexually on the parent body. Spores can be of various types *viz.* **zoospores** (motile and flagellated, *e.g., Chlamydomonas*), **conidia** (non-motile and produced exogenously *e.g., Penicillium*), **chlamydospores** (thick-walled and non-motile *e.g., Rhizopus*), **oidia** (small, thin-walled fragments, *e.g., Agaricus*) and **sporangiospores** (non-motile endospores *e.g., Mucor*).

VEGETATIVE PROPAGATION

The formation of new plants from vegetative units or propagules such as buds, tubers, rhizomes etc. is known as vegetative propagation. It is of two types- natural and artificial (horticultural).

Natural methods

Vegetative propagules of the plant detach naturally from it and develop into new plants under suitable conditions. It takes place by roots, stems, leaves, bulbils and turions.

Artificial methods

Vegetative propagules are developed by horticulturists to quickly multiply desired varieties of plants from parts of their somatic body. It can be done by cutting, layering, grafting, bud grafting and micropropagation.

Roots

Tap roots of some plants develop adventitious buds to form new plants, *e.g., Dalbergia*. In some plants like sweet potato and *Dahlia* root tubers develop adventitious buds which develop into a new plants.

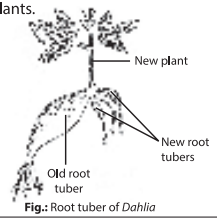


Fig.: Root tuber of *Dahlia*

Leaves

Leaves of many plants have adventitious buds. Such leaves when fall on the ground, their buds develop root, and mature into individual plants, *e.g., Bryophyllum, Begonia* etc.

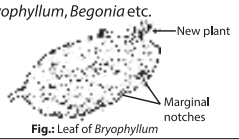


Fig.: Leaf of *Bryophyllum*

Turions

A turion is a swollen bud which contains stored food. It detaches from the parent plant and germinates under favourable conditions *e.g., Utricularia*.

Bulbils

These are multicellular fleshy buds that take part in vegetative propagation, *e.g., Oxalis, Agave* etc.

Fig.: Bulbil of *Agave*

Stems

Certain stem modifications take part in vegetative propagation such as **tubers** (have buds over their nodes or eyes which produce new plantlets when placed in the soil; *e.g.,* potato), **bulbs** (underground condensed shoots with buds which form new plants, *e.g.,* onion), **corms** (unbranched swollen underground stems with circular nodes having buds which germinate into new plants, *e.g., Colocasia*), **rhizomes** (main underground stems with buds which give rise to new aerial shoots during favourable conditions, *e.g.,* ginger), **suckers** (slender underground branches which develop from base of aerial shoot, breaking forms new plants *e.g.,* mint), **runners** (narrow horizontal branches which develop at the base of crown and root at intervals, breaking helps in vegetative propagation, *e.g., Cynodon,*) **stolons** (arched horizontal branches which develop at the base of crown, breaking results in formation of new plant *e.g.,* strawberry), **offsets** (one internode long runners breaking helps in propagation, *e.g., Eichhornia*) and **phylloclades** (each segment of stem can form a new plant, *e.g.,* sugarcane).

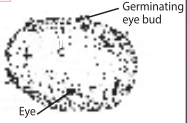


Fig.: Tuber of potato

Cuttings

These are cut pieces of plant parts which are planted in the nurseries. These can be:
(i) **Root cuttings –** The pieces of roots are used to artificially propagate new plants *e.g.,* lemon, orange etc.
(ii) **Stem cuttings –** 20-30 cm long pieces of one year old stems are cut and planted. Before planting they are treated with root promoting chemicals like IBA, *e.g.,* rose, sugarcane etc.
(iii) **Leaf cuttings –** Leaves are cut transversely into 2-3 parts and planted in vertical position in the soil, *e.g., Sansevieria* and *Saintpaulia*.

Bud grafting

Scion is a bud with small piece of bark and cambium. Stock is given a T-shaped cut and bud is inserted in it. The joint is treated with grafting wax and bandaged, *e.g.,* apple, peach etc.

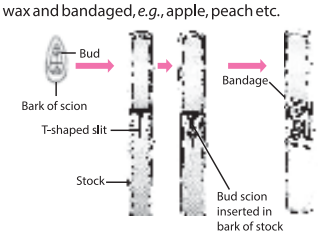


Fig.: Bud grafting

Grafting

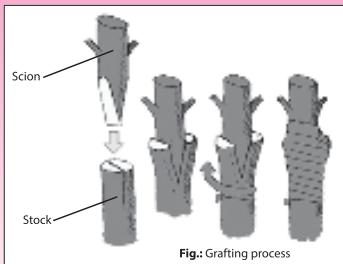


Fig.: Grafting process

Grafting is a technique of connecting two parts, usually a root system and a shoot system of two different plants in such a way that they unite and later develop as a composite plant. A small shoot of plant with superior characters is employed as graft or scion. The root system of the other plant which is disease resistant and has good root system is used as stock (not successful in monocots). It is done in mango, apple etc. The various techniques of grafting are **tongue** grafting, **crown** grafting, **wedge** grafting, **side** grafting and **approach** grafting.

Layering

In this method, adventitious roots are induced to develop on a soft stem by defoliating the soft basal branch and a small injury or cut is given. The injured defoliated part is pegged in the soil to develop adventitious roots. The pegged down branch of the plant is called layer. Once the roots develop, the layer is separated and planted. It can be of following types : **Mound** layering, **Gootee or air** layering, **Simple** layering, **Serpentine** layering and **Trench** layering.

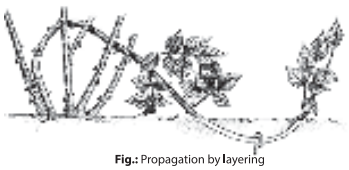


Fig.: Propagation by layering

Micropropagation

This method includes propagation of plants by culturing the cells, tissues and organs. This is known as tissue culture. The culturing results in formation of callus, an undifferentiated mass of cells which later differentiates to form a large number of plantlets. It is useful in obtaining virus free plants, disease free plants, homozygous diploids and quick commercial production of orchids, *Carnation, Gladiolus* etc.

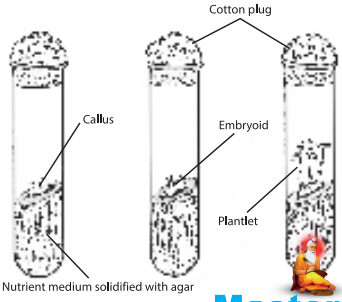


Fig.: Micropropagation

CONCEPT MAP

SEXUAL REPRODUCTION

The process of development of new individuals through the formation and fusion of male and female gametes is known as sexual reproduction or amphimixis or syngenesis.

TYPES

Syngamy

It is the complete and permanent fusion of male and female gametes to form the zygote .

On the basis of source of fusing gametes

Endogamy
It is the fusion of male and female gametes of the same parent, hence, uniparental *e.g., Taenia.*

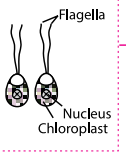
Exogamy
It is the fusion of two gametes produced by different parents, hence, biparental *e.g.,* Rabbit.

Conjugation

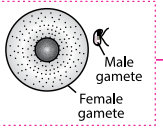
A process of sexual reproduction in which organisms of the same species temporarily couple and exchange or in some cases transfer their genetic material. It takes place in *Paramoecium*, *Spirogyra,* bacteria etc.

On the basis of structure of fusing gametes

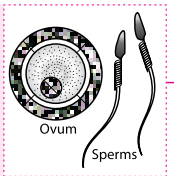
Isogamy
It involves the fusion of gametes which do not differ morphologically but may be different physiologically. It takes place in *Chlamydomonas*.



Anisogamy
It involves the fusion of gametes which differ in size or form. It takes place in *Chlamydomonas,* red algae etc.



Oogamy
It involves the fusion of large non-motile female gamete and a small motile male gamete. It takes place in some algae, vertebrates including human beings and higher invertebrates.



Hologamy
It involves the fusion of two organisms. It occurs in yeasts.

PHASES OF LIFE

Juvenile/Vegetative phase

It is pre-reproductive phase. The period of growth between the birth upto the reproductive maturity of an organism is called the juvenile phase. In plants, it is known as vegetative phase.

Reproductive phase

The period when organisms start producing offspring is called reproductive phase. On the basis of it, plant can be **monocarpic** (flower only once in their life cycle, *e.g.,* bamboo) or **polycarpic** (flower every year in a particular season, *e.g.,* apple).
On the basis of time of breeding, animals are of two types:
(i) **Seasonal breeders:** These animals reproduce at a particular period of the year such as frog, lizard etc.
(ii) **Continuous breeders:** These animals continue to breed throughout their sexual maturity *e.g.,* mice, cattle, etc.

Senescent phase

It is the post-reproductive phase that begins from the end of the reproductive phase. The terminal irreversible stage of ageing is called senescence. It is the last phase of life span and ultimately leads to death.

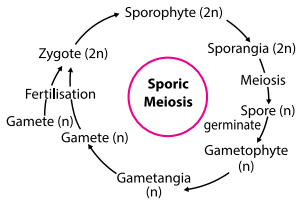
EVENTS IN SEXUAL REPRODUCTION

Pre-fertilisation events

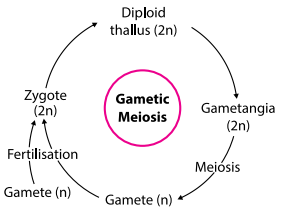
These events of sexual reproduction take place before the fusion of gametes. These include :

Gametogenesis
It is the formation of gametes. Gametes can be **isogametes** (morphologically similar) or **heterogametes** (morphologically dissimilar). Gametes are formed as a result of meiosis which can be of three types:

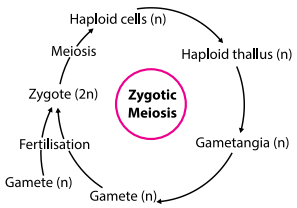
Sporic meiosis occurring inside the sporangia



Gametic meiosis occurring in the germinal cell



Zygotic meiosis occurring in the zygote



Gamete transfer
It is the transfer of gametes to bring them together for fertilisation. In algae, bryophytes and pteridophytes water serves as the medium. In flowering plants it is done by pollination. Animals have copulatory organs to transfer male gametes.

Fertilisation

It is the complete and permanent fusion of two gametes from different or same parent to form a diploid zygote (syngamy). It can be of two types.

External fertilisation
When fertilisation occurs outside the body of the organism, it is called external fertilisation or external syngamy. It requires an external medium such as water, *e.g.,* bony fish and amphibians.

Internal fertilisation
When egg is retained inside female body where it fuses with the male gamete, the process is called internal fertilisation or internal syngamy, *e.g.,* reptiles, birds, mammals etc.

Parthenogenesis

Development of egg (ovum) into a complete individual without fertilisation is known as parthenogenesis. It occurs in rotifers, arthropods, insects etc. It is of two types:

Natural
It occurs regularly in the life cycle of certain animals. It can be complete (occurs in animals which breed exclusively by parthenogenesis), incomplete (occurs in animals in which both sexual reproduction and parthenogenesis occur) and paedogenetic (occurs in larva).

Artificial
In this type, the ovum is induced to develop into a complete individual by artificial stimuli. The stimuli can be physical or chemical.

Neoteny

When the larva retains adult characters such as gonads and starts producing young ones by sexual reproduction, it is called neoteny. It occurs in axolotl larva.

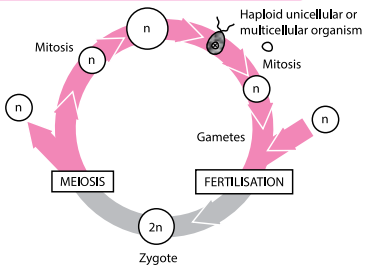
Embryogenesis
During embryogenesis zygote undergoes mitotic cell division and cell differentiation. On the basis of development of zygote, animals can be **oviparous** (egg- laying; zygote develops outside the female body) *e.g.,* all birds, most reptiles etc., **viviparous** (zygote develops inside the female body) *e.g.,* mammals (except egg laying mammals) or **ovoviviparous** (retains egg inside; zygote development is internal) *e.g.,* sharks.
In flowering plants, zygote is formed inside the ovule. After fertilisation the ripened ovary forms the fruit. The ovules mature and get converted into seeds. The ovary wall produces pericarp which protects the seeds.

Post-fertilisation events

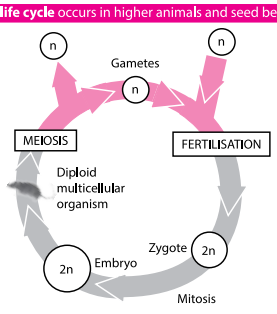
It includes development of zygote and embryogenesis.

Development of zygote
The zygote formed by fusion of two gametes is always diploid. It is a link between one generation and next generation. The development of zygote depends upon the type of life cycle of the organisms and environmental conditions. There are three types of life cycles:

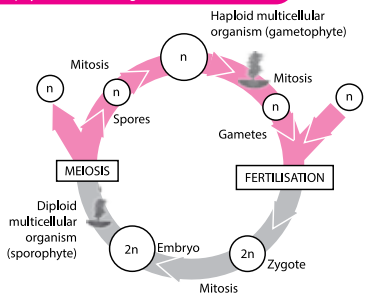
Haplontic life cycle occurs in many algae and fungi



Diplontic life cycle occurs in higher animals and seed bearing plants



Diplohaplontic life cycle occurs in bryophytes, pteridophytes and some algae.



SPECIAL MODES OF REPRODUCTION