UNIT

1 Reproduction

REPRODUCTION IN ORGANISMS

- **Reproduction** is essential for the continuation of the line of **succession** and **maintenance** of a particular species in the **biosphere.**
- The reproduction methods are broadly categorised into 2 types namely – **asexual reproduction and sexual reproduction.**
- **Asexual reproduction** is the production of offspring by a single parent without the formation and fusion of gametes. The young one receives all its genes from one parent, so are identical. Multiplication occurs rapidly. Cell division is by mitosis and is itself a mode of reproduction. Asexual reproduction is common in single celled organisms of plants and animals. Examples- *Amoeba, Paramecium, Euglena, Sycon, Hydra, Planaria,* starfish, water hyacinth, potato, banana, *Bryophyllum,* etc. It is absent in higher invertebrates and all vertebrates.
- **Sexual reproduction** is mostly biparental, involves meiosis, gamete formation and usually fertilization also, introduces genetic variation in the offsprings; and play a role in evolution of species. Found in higher plants and animals.

TYPES OF ASEXUAL REPRODUCTION

- Asexual reproduction takes place in the various ways. These are:

(i) **Fission :** It is the division of the parent body into two or more daughter individuals identical to the parent. It is of two types : (a) **Binary fission :** In this parent organism divides into two halves, each half forms an independent daughter organism. Examples are **bacteria, protozoans and planarians.** (b) **Multiple fission :** In this process the parent body divides into many daughter organisms. It occurs in *Amoeba, Plasmodium.*

(ii) **Budding :** Formation of a daughter individual from a small projection, the **bud,** arising on the parent body is called **budding.** Budding occurs in some protozoans and certain lower animals such as sponges (*Scypha*), coelenterates (*Hydra*), annelids (*Syllis*), yeast and tunicates (*Salpa*).

(iii) **Strobilisation :** In this series of ring like transverse constriction are developed, organism looks like a pile of minute saucers. The segmented body is called a strobila. *e.g., Aurelia.*

(iv) **Fragmentation :** In this the parent body breaks into two or more fragments. Each fragment develops into an organism. Examples: - sponges, sea anemones, echinoderms.

(v) **Gemmae :** These are specialised structures which are green, multicellular, asexual buds, which develop in a small receptacles called gemma cups located on the thalli. Gemmae formation is found in liverworts (*e.g., Marchantia*).

(vi) **Regeneration :** Regeneration is the formation of the whole body of an organism from a small fragment **(morphallaxis)** or the replacement of the lost part **(epimorphosis).**

(vii) **Spore formation :** Spores are propagules which germinate to produce new individuals. There are several kinds of spores. These are **zoospores, sporangiospores, chlamydospores, oidia, conidia.**

(viii) **Vegetative reproduction :** It is the formation of new plants from vegetative units such as **buds, tubers, rhizomes,** etc. These vegetative units are called as **vegetative propagules. While in animals and other simple organisms the term asexual is used unambiguously, in plants, the term vegetative reproduction is frequently used.**

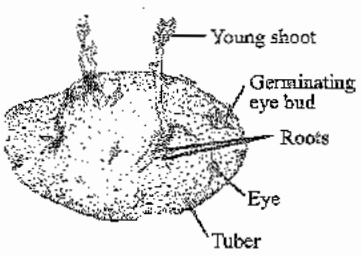

Fig.: Aerial shoots arising from the buds in the regions of nodes eyes in potato tuber

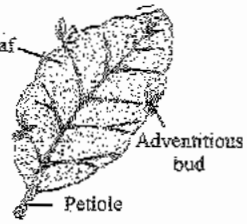

Fig.: A leaf of *Bryophyllum* showing formation of new plants from marginal adventitious buds

- Vegetative reproduction may occur **naturally** or **artificially** as induced by farmers. Among **flowering plants,** every part of the body such as roots, stem, leaves and buds take part in vegetative propagation and is capable of growing into a new plant, in addition to performing its usual functions. The most striking example of such reproductive capacity is seen in the leaves of *Bryophyllum.* More often the capacity for vegetative propagation resides in **roots** (*e.g.,* sweet potato, *Asparagus* and *Dahlia*) or **stems** (*e.g.,* ginger, turmeric, banana, potato, onion, sugarcane). In all these cases the plant parts possess the power of **regeneration.** Thus, rose, *Croton, Duranta* and glory of garden (*Bougainvillea*) are generally propagated by placing their stem cuttings in moist soil. Some very useful plants such as the banana, and certain varieties of oranges are sterile and do not produce any seeds. **Propagation by cuttings** is the only method of obtaining more of these plants.

- Methods of vegetative propagation have been further divided into two types : **natural vegetative propagation and artificial vegetative propagation.**
- The method of plant multiplication occurring naturally in which a somatic part of the plant detaches from the body of the mother and develops into a new plant is called the **natural vegetative propagation.** For example, ordinary roots of *Dalbergia sisso*, *Populus,* guava, *Murraya* sp., *Albizzia lebbek*, etc. can develop adventitious buds which grow to form new plants. **Root tubers** with adventitious buds occur in sweet potato, *Tapioca*, yam, *Dahlia* and *Asparagus*. When placed in the soil, the buds present on the roots grow into leafy shoots called **slips.**
- All types of underground stem structures like **suckers, rhizomes, corms, bulb and tubers** help in vegetative reproduction. Mint and *Chrysanthemum* bears **suckers** at the base of aerial shoots. After growing for some distance the suckers grow out and produce new crowns. **Rhizomes** are thick underground stems which store food for perennation under unfavourable conditions and produce new aerial shoots during the favourable season, *e.g , Typha, Canna,* ginger, turmeric, etc. Plants of *Crocus, Gladiolus, Colocasia,* banana, etc propagate with the help of **corms. Bulbs** of onion, lilies, garlic, etc., serve as means of vegetative propagation by producing new plants when sown in the soil. **Tubers** are modified underground stem branches having several buds. Each eye of the potato tuber is a bud which grows into a new potato plant when planted with a portion of the swollen tuber.
- **Runners** (*Oxalis, Cynodon*), **stolons** (*Vallisneria*) **and offsets** (*Pistia*) **are underground creeping stems.**
- Some plants develop **adventitious buds** on their leaves which get detached and develop new plants. Leaves of *Kalanchoe, Begonia,* develop buds when get injured or detached and placed on the moist soil.
- Some of the **artificial methods** are **cuttings, layering, grafting, micropropagation,** etc.
- The small piece of any plant organ (stem, root or leaf) used for propagation is called **cutting. Leaf cuttings** are used to propagate *Sansevieria, Begonia, Bryophyllum, Kalanchoe*. **Roots cuttings** are used to propagate lemon, tamarind, blackberry, etc. **Stem cuttings** of 20-30 cm long are most commonly used for artificial vegetative propagation.
- **Layering** is a method in which roots are **artificially induced** on **stem branches** before they are detached from the parent plant for propagation.
- **Grafting** is the most common method of vegetative propagation described by ancient gardeners long before the science of horticulture became established. In this method, parts of two plants are joined in such a way that they grow as one plant.
- **Micropropagation** is a method which includes propagation of plants by culturing the cells, tissues or organs, called **tissue culture.** Initially, the culturing of cells or tissues results in the formation of an undifferentiated mass of cells, called **callus,** which later differentiates to produce a large number of plantlets. After transforming into growth regulator cytokinins and Auxins. These **plantlets** are then transferred to separate pots or nursery beds to obtain a large number of plantlets.

Advantages of vegetative propagation

- The advantages of vegetative propagation are:
  - Growing of some seedless fruit plants like banana, seedless grapes and oranges, rose, jasmine, sugarcane, etc.
  - Vegetative propagation is the only means to produce genetically identical offspring and preserve a stock of desired variety.
  - It is an easier, less expensive and a rapid method of propagation.
  - Superior quality flowers and fruits can be produced by the method of grafting.
  - A large number of disease free identical plants can be grown in a very short time by tissue culture technique.

Disadvantages of vegetative propagation

- The disadvantages of vegetative propagation are:
  - Good qualities cannot be introduced nor bad characters eliminated in plants multiplied through vegetative propagation.
  - Disease contracted by a parent spreads to all the daughters cells.
  - Vegetative organs useful for propagation cannot be preserved for long.
  - Vegetative propagules are not so efficiently protected as the seeds are. They get easily decayed and are prone to various viral, fungal and bacterial diseases.
  - There are no variations. Therefore, the plants may show degeneration and in such plants there is a less adaptability to changed environment.
  - There is no dispersal of vegetative propagules. Therefore, it causes **over-crowding.**

SEXUAL REPRODUCTION

- It is the process of development of new individual through the formation and fusion of male and female gametes. Sexual reproduction is also called **amphimixis** (Gk. *amphi*-both, *mixis* -union) or **syngenesis** (Gk, *syn*-together, *genesis*-origin) or **amphigony** (Gk. *amphi*-both, *gony*-marriage).
- All the organisms grow to a certain maturity in their life before they start reproducing sexually. The period of growth between their birth upto their reproductive maturity is called the **juvenile phase.** In plants, the period of growth between seed germination upto initiation of flowering is called **vegetative phase.** The later part, when the organisms start reproducing sexually, is called **reproductive phase.** The juvenile phase is of variable duration in different organisms.
- In **animals,** the **juvenile phase** is followed by morphological and physiological changes prior to active reproductive behaviour. The **reproductive** phase is also of variable duration in different organisms.

Events in sexual reproduction

- The events of sexual reproduction are elaborate and complex but follow a regular sequence in all sexually reproducing organisms. For convenience these sequential events may

be grouped into three distinct stages namely, the **pre-fertilization**, **fertilization** and the **post-fertilization** events.

Pre-fertilization events

- These are the events of sexual reproduction which takes place before fusion of gametes. These include, **gametogenesis** and **gamete transfer**.

(i) **Gametogenesis :** The process of formation of gametes is known as gametogenesis. The reproductive units in sexual reproduction are specialised cells called gametes. The **gametes** are generally of two kinds : male and female. In some lower plants (*i.e.*, in some algae), the two gametes are morphologically similar, Such gametes are called **isogametes** (or **homogametes**). When male and female gametes are morphologically distinct they are called **heterogametes.** In such organisms, male gametes are called **microgametes,** or **spermatozoa,** and female gametes termed **macrogametes,** or **ova.** Male gametes are usually motile and smaller in size. Whereas female gametes are larger in size and always immotile.

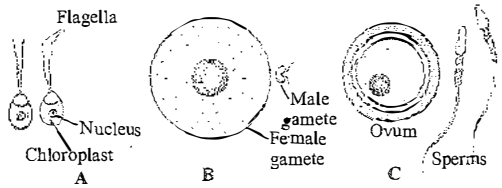

Fig.: Types of gametes, A. Isogametes of *Cladophora* (an alga). B. Heterogametes of *Fucus* (an alga) and C. Heterogametes of human beings.

- Sexual reproduction in organisms generally involves the fusion of gametes from two different individuals.
- In plants when both male and female reproductive structures are present on the same plant then these plants are called as **bisexual** and when these reproductive structures are present on different plants then these plants are referred as **unisexual.** In some fungi and plants bisexual condition is referred as **monoecious** and **homothallic,** and for unisexual condition **heterothallic** and **dioecious** terms are used. In flowering plants, the unisexual male flower is staminate, *i.e.*, bearing stamens, while the female is pistillate or bearing pistils. In some flowering plants, both male and female flowers may be present on the same individual (**monoecious**) or on separate individuals (**dioecious**). Some examples of monoecious plants are **cucurbits** and **coconuts** and of dioecious plants are **papaya** and **date palm.**
- In some lower animals both male and female sex organs are present in the same individual. These animals are called **hermaphrodite** or **bisexual,** *e.g.*, tapeworm, earthworm and leech.
- **Cell division during gamete formation :** The gametes are usually formed by **meiotic divisions.** Therefore, they are **haploid.** The male and female gametes fuse to form a single cell, the **zygote.** This process is called **fertilization.** The zygote formed by the fusion of two haploid gametes is naturally **diploid.** In diploid organisms, specialised cells called **meiocytes** (gamete mother cell) undergo meiosis. At the end of **meiosis,** only one set of chromosomes get incorporated into each gamete.

(ii) **Gamete transfer :** In most of organisms male gamete is motile and the female gamete is non-motile. A medium is needed through which male gametes move. In algae, bryophytes and pteridophytes, water serves as the medium through which gamete transfer takes place. Since several male gametes fail to reach the female gametes, hence the male gametes are produced in larger number, *i.e.*, several thousand times more than the female gametes.

- In flower bearing plants, pollen grains carry the male gametes which are produced in large number. The pollen grains are transferred to the stigma of the female organ (carpel) through the process of **pollination.**

Fertilization

- The fertilization is the complete and permanent fusion of two gametes from different parents or from the same parent to form a diploid zygote. This process is also called **syngamy.**
- When fertilization occurs outside the body of the organism, this type of gametic fusion is called **external fertilization or external syngamy.** The external medium such as water is required for this type of fertilization. Thus, in most aquatic organisms such as a majority of algae, fishes, and amphibians, external fertilization occurs.
- When egg is formed inside the female body where it fuses with the male gamete, the process is called **internal fertilization or internal syngamy.** Many terrestrial organisms belonging to fungi, higher animals such as reptiles, birds and mammals and majority of bryophytes, pteridophytes, gymnosperms and angiosperms are the examples where internal fertilization occurs. Large number of offsprings are produced in such organisms and their offsprings are highly vulnerable to predators.

Post-fertilization events

- It is described under two headings : zygote and embryogenesis.

(i) **Zygote :** After fertilization a diploid zygote is formed in all sexually reproducing organisms. Further development of the zygote depends on the type of life cycle of the organism and environmental conditions.

(ii) **Embryogenesis** : The process of development of embryo from the zygote is called embryogenesis. During embryogenesis zygote undergoes mitotic cell division and cell differentiation. Cell division increases the number of cells in the developing embryo while cell differentiation helps to form specialised tissues and organs to form an organism.

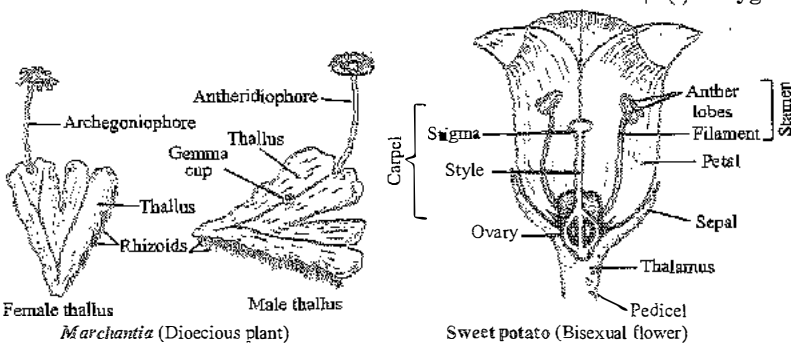

Fig.: Diversity of sexuality in organisms

- On the basis of the development of the zygote, animals are grouped into **oviparous, viviparous** and **ovoviviparous.** The oviparous animals such as reptiles and birds lay eggs. In viviparous animals such as majority of mammals including human beings, the zygote develops into a young one inside the body of the female individual. In ovoviviparous animals, the female retains the eggs inside its body after fertilization and allows the development of the embryo inside the body without providing extra nourishment to the developing embryo as the placenta is absent. Examples are sharks and rattle snakes.
- In flowering plants, the zygote is formed inside the ovule of the female sex organs. The **fertilized ovule** mature and convert into seeds. The wall of the ovary produces the pericarp (fruit wall). The ripened ovary enclosing the seeds forms fruits. The pericarp protects the young seeds. After dispersal the seeds germinate to form new plants.

Advantages of sexual reproduction

- The advantages of sexual reproduction are :
  - Genetic recombination takes place causing variations.
  - Variation being a major factor of natural selection, therefore, it plays an important role in evolution.
  - Genetic recombination, interaction, etc. during sexual reproduction provide vigour and vitality to the offspring.
  - The offsprings produced adapt better to the changing environmental conditions