

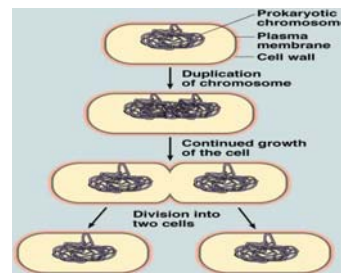
Reproduction in Plants

- * The period from birth to natural death of an organism is called as Life span.
- * Life span varies from plant to plant. Some survive for few days and some few thousands of years.
- * Mango has less life span than a Peepal tree. Banyan tree survives for hundreds of years, *Osmunda* a few hundred years, *Pinus* few thousands of years, Carrot 2 years, Banana one year, Rice a few months, Rose few years and moss plant few weeks. *Wolfia* also a few weeks.
- * Every organism has to die except in case of single celled organism which are immortal.
- * The existence of various types of plant species since thousands of years is due to their ability to reproduce.
- * Reproduction is production of younger individuals by an organism which are similar to the parental organism. This offspring grows, matures and produces new offspring. There is a cycle of birth, growth and death.
- * Reproduction enables continuity of species. Every organism has its own mechanism of reproduction which is dependent on the habitat, physiological status and several other factors.
- * Reproduction is of two types whether either one or two organisms are involved in it and participation of gametes or not. These are asexual reproduction and sexual reproduction.

Asexual reproduction

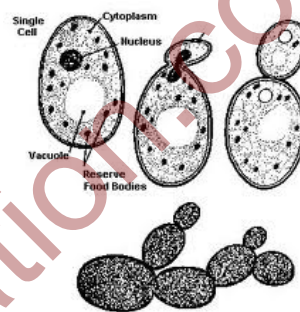
- * It is production of new individuals from a single individual.
- * New organisms produced are identical to their parent and exact copies of the parent.
- * It is common in single celled organisms and in plants with relatively simple organization.

- * In Monerans and Protists the parental cell divides and gives rise to two organisms and cell division itself is the mode of reproduction in these organisms.



- * Many single-celled organisms reproduce by binary fission where a cell divides into two halves and each one rapidly develops into an adult. Ex: Bacteria, Euglena.

- * In **yeasts**, the asexual reproduction takes place by **budding** where the division is unequal. Small buds are produced that remain attached initially to the parental cell which eventually get separated and mature into new yeast cells.



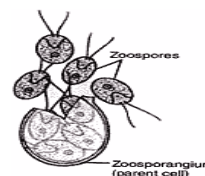
- * Fungi and Algae mainly reproduce through asexual spores. These spores are microscopic, adapted for dispersal, and can survive extended periods of unfavorable conditions.

- * Motile flagellated spores are called Zoospores.

Ex: *Chlamydomonas*

- * Non-motile asexual spores with thin walls are called as Aplanospores. Ex: Bread mould (*Rhizopus*).

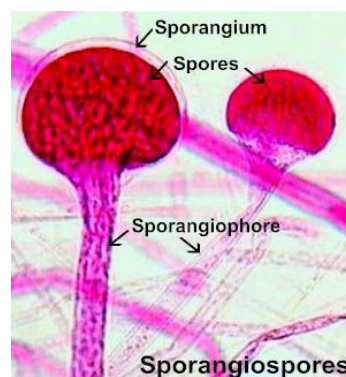
- * In fungi like *Penicillium*, the spores are produced on specialized structures called as Conidiophores. The spores are called as Conidia.



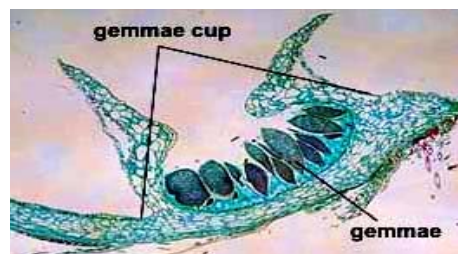
- * In Bryophytes and Pteridophytes, the spores are haploid in nature and upon germination they give rise to gametophytes which are necessary to complete the life cycle.

- * Vegetative reproduction is another type of asexual reproduction.

- * Fragmentation is a type of vegetative reproduction in which the multicellular body is broken into pieces and each piece develops into an organism. It is seen in Multicellular algae, moulds and mushrooms.



- * In Liverworts like *Marchantia*, the specialized structures called Gemmae are formed in cup like structures via fragmentation.
- * In flowering plants, the vegetatively reproductive units are Runners, Stolons, Suckers, Offsets, Rhizomes, Corms, Stem Tubers, Bulbs, Bulbils and reproductive leaves. These are called as Vegetative Propagules. Progeny obtained vegetatively is called as Clone.
- * Water Hyacinth (Terror of Bengal) grows at phenomenal rates due to vegetative propagation in stagnant fresh water bodies. It drains oxygen from water and cause of death of fishes. It is very difficult to eradicate it because it grows very fast. This plant was introduced into India because of its beautiful flowers and shape of leaves.
- * Plants like Potato, Sugarcane, Banana, Ginger, and Dahlia are cultivated through vegetative propagation. In these plants small plants emerge at nodes from axillary buds. When the nodes come in contact with moisture they form adventitious roots and develop as new plants. Likewise adventitious buds arise from the notches of leaf margin of *Bryophyllum*. This ability is exploited by gardeners for commercial propagation of plants.
- * Asexual reproduction is most common type of reproduction in plants with simple organization like algae and fungi which revert to sexual reproduction at the onset of adverse conditions.



Sexual Reproduction

- * Sexual reproduction includes the production of male and female gametes either on the same individual or different individuals, fusion of gametes, formation of zygote and development of new organism from zygote.

- * The new organisms formed do not exactly resemble among themselves as well as with the parents.
- * It is long, complex and slow process when compared to asexual production.
- * All sexual reproducing organisms share a common pattern though they show differences in their external morphology, internal morphology and physiology.
- * All organisms before reproducing sexually have to complete their vegetative growth and attain maturity. This vegetative phase varies from organism to organism.
- * The end of vegetative phase of a flowering plant can be noticed easily when the plant starts producing flowers.
- * Some plants flower only once in their life cycle (*Agave*, *Bamboo*). While other flower several times in their life span (*Mango*, *Neem*). Some plants flower only in particular season where as others flower any time in a year after completing vegetative growth.
- * Annuals, biennials clearly show vegetative, reproductive and senescent phases but in perennials it is difficult to define these phases (inter-flowering period cannot be identified as mature or immature).
- * Annuals like Paddy, Wheat, Maize flower only once at the end of their growing season. Biennials flower in the second year. Perennials like bamboo flowers only once at the end of its life span i.e. after 50-100 years. *Agave* flowers after 10-30 years. The plant *Neelakurinji* (*Strobilanthes kunthiana*) flowers once in every 12 years. This plant grows on the hill tracts of Tamilnadu, Karnataka and Kerala.
- * The reproductive period varies from organism to organism.
- * In plants Phytohormones play a key role in reproduction. Hormones and environmental factors like light and temperature regulate the reproductive phase of plants.

Events in Sexual Reproduction

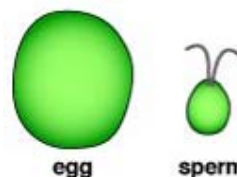
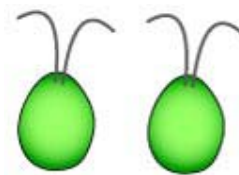
- * Events of sexual reproduction include formation of gametes, fusion of gametes, formation of zygote, formation of embryo and seedling or young plant. These are studied under three stages as Pre-fertilisation, Fertilisation and Post-fertilisation events.

Pre-fertilisation events

- * These are events before the fusion of gametes. These include gametogenesis and gamete transfer.

Gametogenesis

- * It is formation of gametes. Male and female gametes may be formed on the same plant or on different plants.
- * In some plants like alga *Cladophora*, male and female gametes are similar and these are called as **Homogametes** or **Isogametes**.
- * In most of the plants male and female gametes are morphologically distinct and such gametes are called as **Heterogametes**. Ex: *Fucus*, *Pteris*, *Cycas*



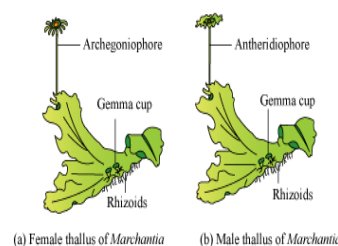
Sexuality in Organisms

- * In sexual reproduction either gametes formed on the same plant may be involved or gametes of different plants are involved.
- * If both male and female sex organs are present on the same plant of a species, the species is described as **homothallic** in case of fungi or **monoecious** in case of algae (*Chara*) embryophytes. (Maize).
- * If male and female sex organs are present on different plants of the same species, the species are described as **heterothallic** in fungi and **dioecious** in case of embryophytes.



- * In flowering plants the flowers may be unisexual or bisexual. Unisexual flowers with androecium are described as male or **staminate** flowers and that with gynoecium as female or **Pistillate** flowers.

- * In **monoecious** flowering plants both male and female flowers are present on the same plant as in Cucurbits and Coconut. If male and female flowers are present on different plants, it is described as **dioecious** as in Papaya and Date palm.



Cell Division during gamete formation

- * Gametes are haploid as they have only one set of chromosomes. In organisms such as Protista, Algae, Fungi and Bryophytes, the main plant body is haploid. During gamete formation they show mitosis. These organisms show meiosis either in their zygote or in spore mother cells. In Pteridophytes, Gymnosperms and Angiosperms, gametes are formed in gametophytes by mitosis. These plants show meiosis during spore formation. These spores germinate and form gametophytes in which gametes are formed by mitosis. The cells that undergo meiosis are called as meiocytes. These are spore mother cells (Bryophytes, Pteridophytes and Spermatophytes) or gamete mother cells (*Fucus*, Diatoms).

Gamete Transfer

- * The male and female gametes must be brought together after their formation for fertilization.
- * In most of the plants the male gametes are motile and female gamete is stationary. In some algae and fungi both male and female gametes are motile e.g. *Cladophora*.
- * In **Algae, Bryophytes and Pteridophytes**, water acts as medium for transfer of male gametes. Most of the male gametes fail to reach the female gametes. Hence to ensure gametic union large numbers of male gametes are produced in male gametangia which are thousand times more in number than female gametes produced.

- * In **Seed plants**, the pollen grains are the carriers of male gametes. Ovules have egg in their embryo sac or female gametophyte. In plants with bisexual flowers showing self-fertilization, pollen grains easily reach stigma of gynoecium after their release from anther as the distance between the stamen and gynoecium of flower is less. In cross pollinated plants, the pollen grain has to travel some distance before reaching the stigma of some other flower usually through wind, water and animals like insects. When pollen grains germinate on the stigma they form pollen tube. In the pollen tube male gametes are formed. Thus the male gametes are carried by pollen tube towards the egg cell present in the ovule.



Fertilisation

- * It is the most vital event of reproduction. It is fusion of male and female gametes. It is also known as syngamy.
- * Formation of embryo from egg cell without the act of fertilization is called as **Parthenogenesis**. Formation of fruit without the act of fertilization is called as **Parthenocarpy**.
- * If fertilization takes place outside the plant body such as water as in Algae, it is called as **External Fertilisation**. Organisms with external fertilization maintain synchrony in sexes, release of male and female gametes and maturation of sex organs.
- * In many terrestrial organisms belonging to fungi and embryophytes, fertilization takes place inside the body of organism. It is called as **internal fertilization**. In organisms (Bryophytes, Pteridophytes) with such fertilization, the egg is formed inside the body and the male gamete is motile and reaches the egg cell through the agency of water. The number of egg cells produced is considerably less when compared with the male gametes.
- * In seed plants the non-motile male gametes are carried to egg cell by pollen tubes.

Post fertilization Events

- * These are the events than occur after fertilization.

Zygote

- * It is the product of syngamy. It is diploid. It is universal in all sexually reproducing organisms. In external fertilization organisms it is formed externally in the water and in internal fertilization organisms it is formed in the body of organism.
- * Further development of zygote depends on the type of life cycle of organism and the type of environment it is exposed to.
- * In Algae and Fungi the zygote develops a thick wall and becomes resistant to desiccation and damage. It undergoes a period of rest before germination. In organisms with haplontic life cycle it undergoes meiosis to form haploid spores which develop into haploid organisms. In organism with Diplontic life cycle it enlarges and divides to form a diploid individual and later in the organism meiosis takes place at the time of gamete formation as in Fucus.
- * In Embryophytes, the zygote develops into embryo which eventually forms the diploid adult individual known as Sporophyte.
- * Zygote is the vital link between two successive generations. It ensures continuity of species. Every sexually reproducing organism begins with single cell called Zygote.

Embryogenesis

- * It is development of embryo from zygote as result of mitotic divisions and cell differentiation. Cell differentiation helps in the formation of various types of tissues and organs to form an organism.
- * In flowering plants the zygote is formed inside the ovule. After fertilization, petals, sepals, stamens are shedded off. In some plants like Tomato and Brinjal, the sepals do not fall off and remain with the fruit. The zygote develops into embryo. The ovules become seeds and the ovary develops as fruit. The fruit wall is called as Pericarp.

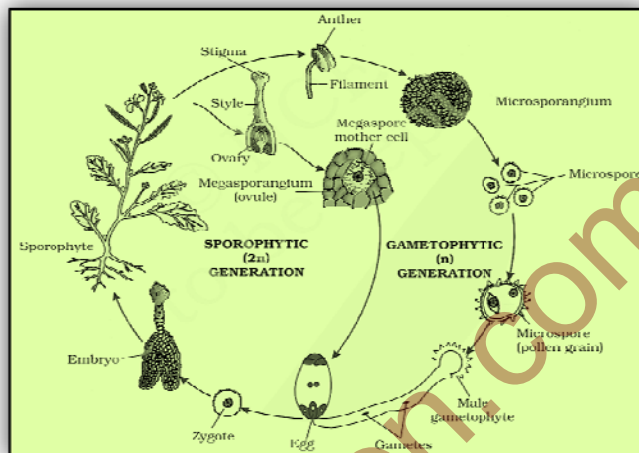
- * After dispersal of fruits and seeds, the seeds germinate and develop into new plants.
- * In some plants like Mangroves, the seed germinate when they are still inside the fruit attached to parental plant and the phenomenon is called as **Vivipary**. It is a strategy of the plant to withstand the environmental stress and ensuring successful establishment of plantlets.



Over view of Angiosperm Life cycle

- * In Angiosperms the pollen grains and embryosacs are developed in specialized structures called as Flowers.
- * Flower has male sex organ called androecium consists of stamens and female sex organs gynoecium consisting of carpels.
- * Stamen has a filament and anther. Anther has microsporangia which have microspore or Pollen mother cells that form haploid microspores or pollen grain by meiosis.
- * Gynoecium or carpel has ovary which has one or more ovules. Each ovule has diploid tissue nucellus. A cell of nucellus behaves as megaspore mother cell which undergoes meiosis and forms megaspores.
- * Megaspore is the first cell of female gametophyte. It undergoes free nuclear divisions for 3 generations and forms 8 nuclei four at each pole. One of the nuclei of each pole migrates towards the center of the cell and later cell walls are formed around the nuclei of respective poles to form a 7-celled 8-nucleated structure called embryosac. It has an egg cell, two synergids, a central cell and 3 antipodals. Egg cell and central cell are involved in fertilization.

- * Pollen grains are released from the anther at 2-celled stage (Generative cell, Vegetative cell). These are carried to stigma (Pollination) by various agents like wind, water and animals. They germinate on the stigma, form pollen tubes, which have two male gametes formed from generative cell and a vegetative nucleus. The pollen tube seeks entry into the embryosac of ovule through synergids and releases the two male gametes into the embryosac.



- * The process of fertilization is double fertilization. One male gamete fuses with the egg cell and forms zygote. The second male gamete fuses with the two polar nuclei or diploid secondary nucleus to form triploid primary endosperm nucleus. The synergids and antipodals perish after fertilization.
- * The PEN forms endosperm which nourishes the zygote to develop into embryo. The ovules transform into seeds and the ovary into fruit.
- * In the life cycle the dominant stage is diploid sporophyte which is the main plant body. The gametophyte is reduced and multicellular. It is parasitic on sporophyte.
- * In the life cycle, the diploid sporophyte is dominant which gives rise haploid micro and megaspores by meiosis that later develop as male and female gametophytes. The life cycle is haplo-diplontic life cycle.