Reproduction in Organisms

The period from birth to natural death of an organism represents its **lifespan**. The lifespan of an organism is not necessarily correlated with their body size, it can vary from one day to more than 400 years as shown in the table below

Lifespan of Some Organisms

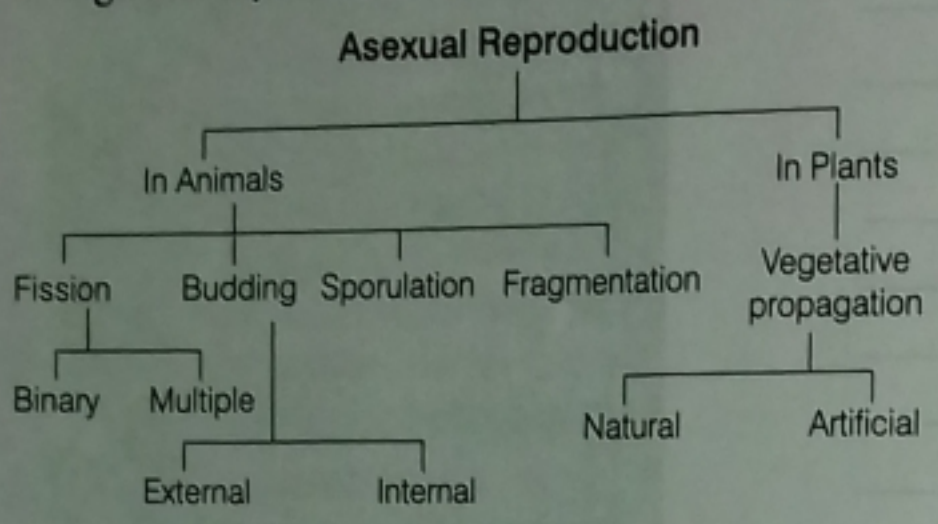
Organism	Lifespan	Organism	Lifespan
Mayfly	1 day	Monkey	26 yrs
Butterfly	1-2 weeks	Horse	60 yrs
Fruitfly	30 days	Crocodile	60 yrs
Rice plant	3-4 months	Elephant	65 yrs
Wheat plant	6 months	Man	100 yrs
Rose	5-7 yrs	Tortoise	100-150 yrs
Dog	10-13 yrs	Parrot	140 yrs
Crow	15 yrs	Mango tree	150-200 yrs
Cow	20-25 yrs	Banyan tree	200-250 yrs
Banana tree	25 yrs	*Sequoia*	3000-4000 yrs

Irrespective of long or short lifespan of an organism, death is a certain phenomenon, i.e. no individual is immortal, except single-celled organisms like *Amoeba*. So, there must be some processes in living organisms that ensure continuity of species.

This process is reproduction. In this chapter, we will study the different modes of reproduction present in various species and the importance of this process.

TOPIC 01 Asexual Reproduction

When the offspring is produced by a single parent without the involvement of gametic fusion, the reproduction is called as **asexual reproduction**. It involves only mitotic cell division. Meiosis does not occur in asexual reproduction. Offsprings produced by asexual reproduction are identical to one another and exact copies of their parents. Such a group of morphologically and genetically similar individuals are called **clone**.



Asexual reproduction occurs in unicellular organisms (monerans and protists), some lower animals (sponges, coelenterates, certain worms), plants and tunicates. It is absent in higher invertebrates and vertebrates.

Asexual Reproduction in Animals

Asexual reproduction is common among single-celled organisms and animals with relatively simple organisation.

In lower organisms like protists and monerans, the organism or the parent cell divides into two, to give rise to new individuals. Thus, in these organisms **cell division** is itself a mode of reproduction.

Asexual reproduction in animals occurs by the following methods

Fission

It is the division of the parent body into two or more daughter individuals identical to the parent. It can occur by binary fission and multiple fission.

1. **Binary fission** It is the division of the parent cell into two small, nearly equal sized daughter individuals, each of which rapidly grows into an adult. It occurs in single-celled animals like bacteria and protozoans, e.g. *Amoeba, Paramecium, Euglena*, etc.

Types of Binary Fission

Various types of binary fission are as follows

(i) **Transverse binary fission** The fission in which plane of cytoplasmic division coincides with the transverse plane of an individual, as seen in *Paramecium, Vorticella.*

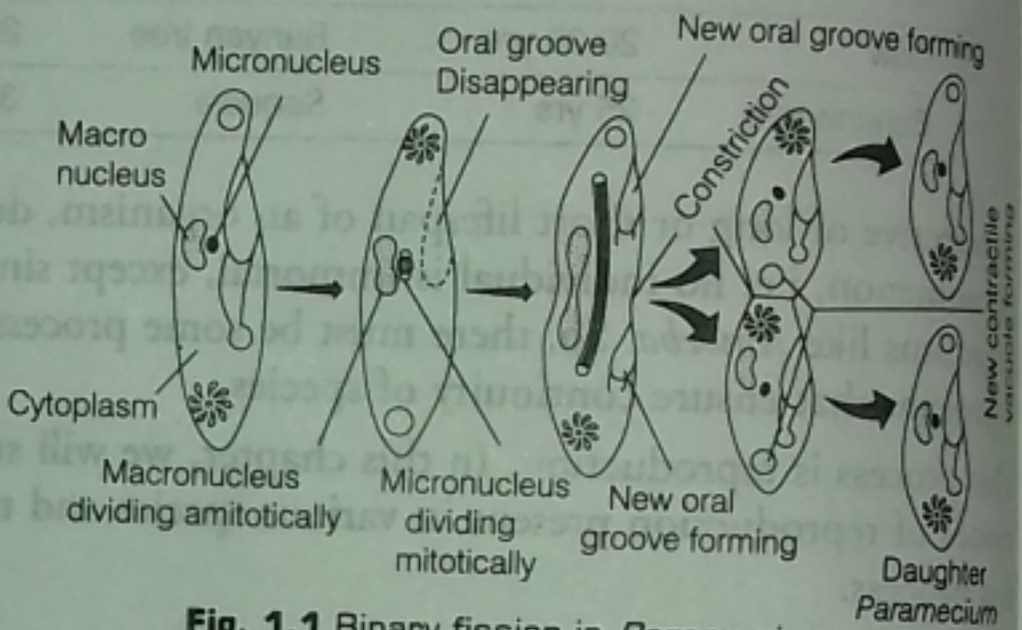


Fig. 1.1 Binary fission in *Paramecium*

(ii) **Longitudinal binary fission** Coincides with the longitudinal plane of individual, e.g. *Euglena*.

(iii) **Oblique binary fission** When division occurs at an angle to the transverse axis, e.g. *Ceratium gonyaulax*.

(iv) **Irregular or Simple binary fission** The fission in which plane of cytoplasmic division is not fixed, and division can occur in any plane, but it is always right angle to the elongated dividing nucleus, e.g. *Amoeba*.

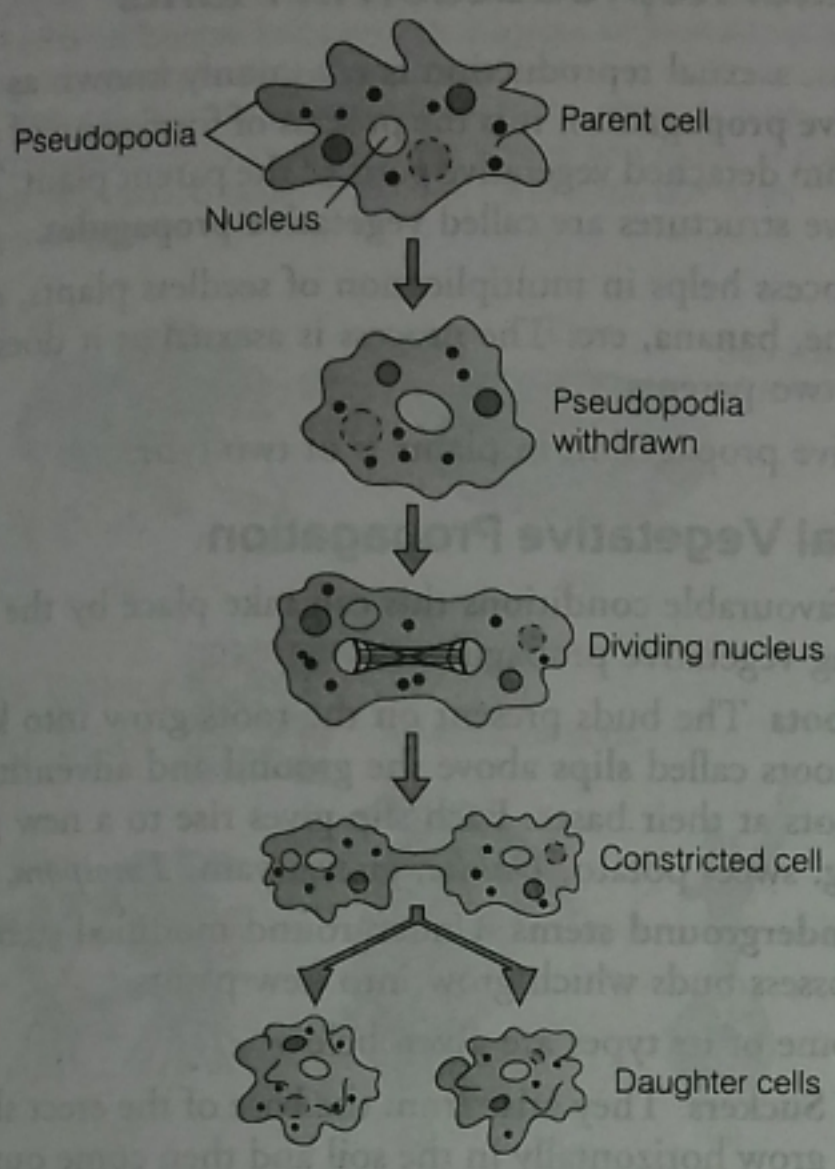


Fig. 1.2 Binary fission in *Amoeba*

2. **Multiple fission** It is the division of the parent body into many small daughter individuals simultaneously, each of which grows into an adult, e.g. *Plasmodium* (the malarial parasite), *Amoeba* (during unfavourable conditions), etc.

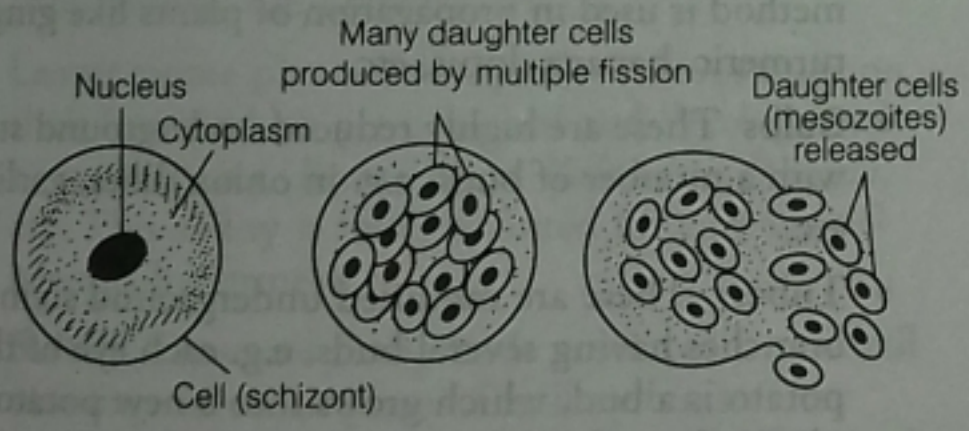


Fig. 1.3 Multiple fission in *Plasmodium*

Budding

It is a mode of asexual reproduction in which one or more unequal and small projections called **buds** are produced that remain attached initially to the parent cell, but eventually get separated and mature into new organisms, e.g. yeast, *Hydra*, etc.

Depending on the place where the bud arises, budding can be of two types

1. **External budding** (*Hydra* and yeast) In *Hydra*, (multicellular organism) regenerative cells are used for reproduction during budding. A bud develops as an outgrowth due to the repeated cell divisions at one specific site. These buds develop into tiny individuals which on getting fully matured, detach themselves from the parent body becoming new independent individuals.

Note The complex budded condition of the parent body is known as **torula** stage.

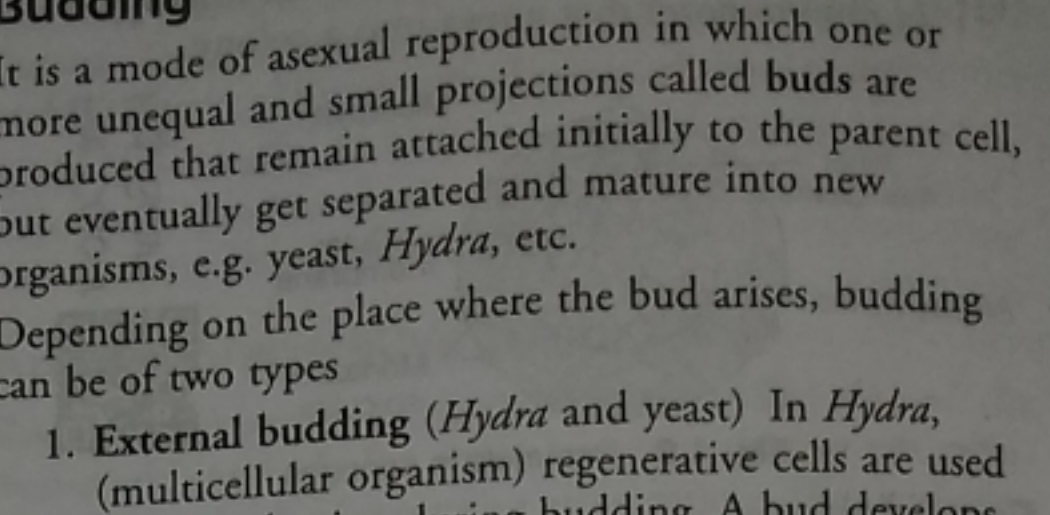


Fig 1.4 Budding in *Hydra*

The same process occurs in yeast, where nucleus divides by the process of budding into a new bud which gets detached from parent yeast.

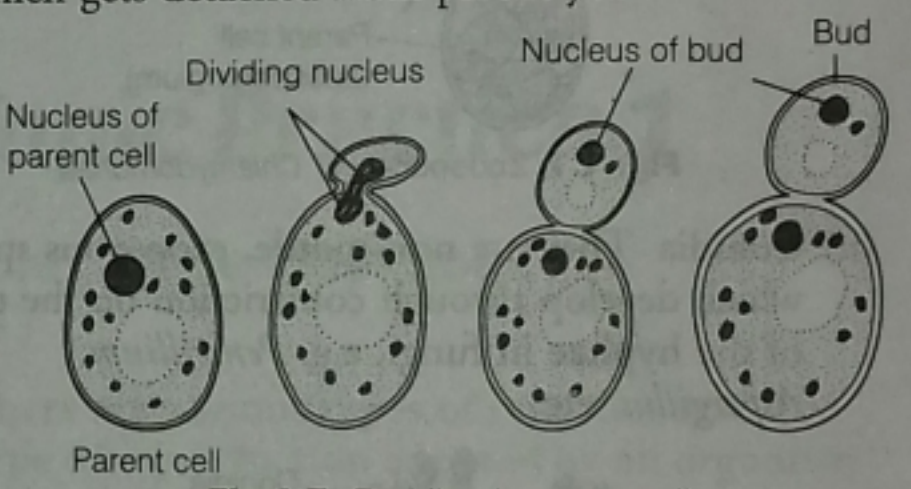


Fig.1.5 Budding in yeast cell

2. **Internal budding** (Gemmule formation) A mass of cells enclosed within a common opaque envelop, rich in food, which germinates into a new plant, is called a **gemmule**. Gemmule formation is common in freshwater sponges (e.g. *Spongilla*) and a few marine sponges. Each gemmule has a group of cells called **archaeocytes** surrounded by the protective covering. During adverse environmental conditions,

a mass of archaeocytes comes out *via* micropyle (a minute pore) that grows into a colony.

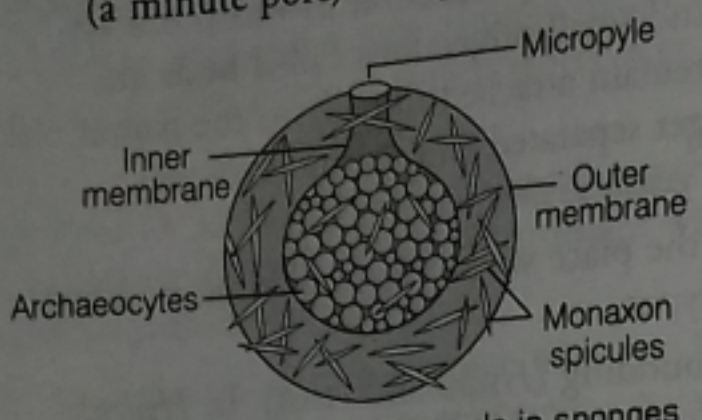


Fig. 1.6 Gemmule in sponges

For Colour Fig. Scan

Sporulation

The process of formation of spores is known as sporulation. It is mode of reproduction in Monera, Protista, Algae and Fungi. These spores are minute, single-celled, thin or thick-walled propagules. In unfavourable condition, vegetative propagation in plants occurs by spore formation. Different organisms produce different types of spores as given below

(i) **Zoospores** They are microscopic motile structures with one or two flagella. The flagella helps the zoospores to swim in aquatic habitat for proper dispersal. These are the most common reproductive structures seen in members of the kingdom–Fungi and simple plants such as algae, e.g. *Chlamydomonas, Albugo, Ulothrix,* etc.

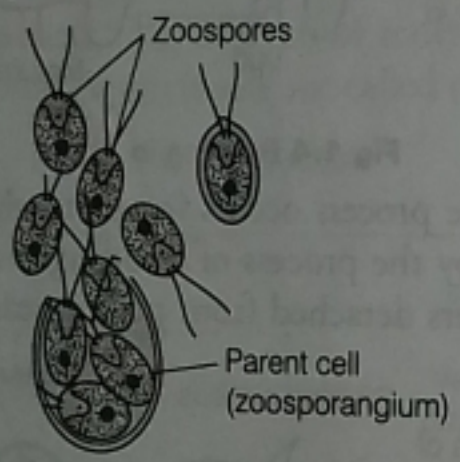


Fig. 1.7 Zoospores of *Chlamydomonas*

(ii) **Conidia** They are non-motile, exogenous spores, which develop through constriction on the tips of the hyphae in fungi, e.g. *Penicillium, Aspergillus,* etc.

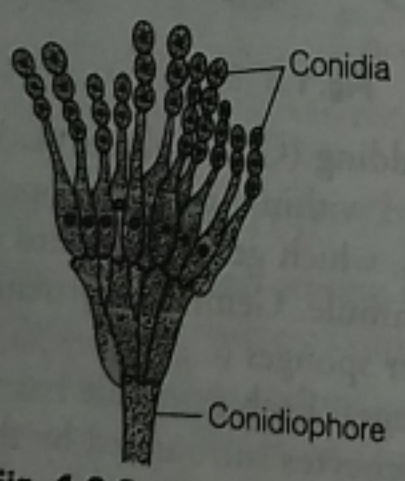


Fig. 1.8 Conidia of *Penicillium*

Fragmentation

It is a mode of asexual reproduction in which parental body breaks into distinct pieces, each of which regenerates into an offspring. It is found in sponges, sea anemone (coelenterates) and echinoderms. It is also found in algae (e.g. *Spirogyra*), fungi, etc.

Note Algae and fungi, though reproduce asexually can switch to sexual methods just before the onset of adverse conditions. Higher plants also exhibit sexual as well as asexual modes of reproduction.

Asexual Reproduction in Plants

In plants, asexual reproduction is commonly known as **vegetative propagation**. It is the process of formation of a new plant from detached vegetative parts of the parent plant. These vegetative structures are called **vegetative propagules.**

This process helps in multiplication of seedless plants, e.g. sugarcane, banana, etc. The process is asexual as it does not involve two parents.

Vegetative propagation in plants is of two types

Natural Vegetative Propagation

Under favourable conditions this can take place by the following vegetative propagules

1. **Roots** The buds present on the roots grow into leafy shoots called **slips** above the ground and adventitious roots at their bases. Each slip gives rise to a new plant, e.g. sweet potato, *Dahlia*, guava, yam, *Tinospora*, etc.
2. **Underground stems** Underground modified stems possess buds which grow into new plants.

   Some of its types are given below

   - **Suckers** They arise from the base of the erect shoot, grow horizontally in the soil and then come out to form new aerial shoots. These shoots become independent when suckers break away from the parent plants, e.g. pineapple, mint, *Chrysanthemum*, etc.
   - **Rhizomes** These are modified stems with buds and sufficient food storage. A piece of rhizome containing bud can give rise to a new plant. This method is used in propagation of plants like ginger, turmeric, banana, lotus, etc.
   - **Bulbs** These are highly reduced underground stems with a number of buds, e.g. in onion, lilies, garlic, etc.
   - **Tubers** These are modified underground stem branches having several buds, e.g. each eye of the potato is a bud, which grows into a new potato plant when planted with a portion of swollen tuber. The potato crop is raised by the tubers not by seeds.

3. **Creeping stems** Vegetative propagation by the means of creeping stems, can be categorised as under
   - **Runners** These are modified stems, which produce adventitious roots at nodes. Each node gives rise to an aerial shoot which becomes a new plant, e.g. *Oxalis*, *Centella*, grasses, etc.
   - **Offsets** These are one internode long runners, which develop tuft of leaves at the apex, e.g. *Pistia* (water lettuce), *Eichhornia* (water hyacinth), etc.

Note Water hyacinth (*Eichhornia*) is an aquatic plant which is also called **Terror of Bengal** because it propagates vegetatively at an alarming rate and spreads over the water body in a short period of time. It drains O_2 from water which leads to the death of fishes. It was introduced in India for its beautiful flowers and shape of leaves but eventually caused death of the rivers and lakes due to its uncontrolled growth.

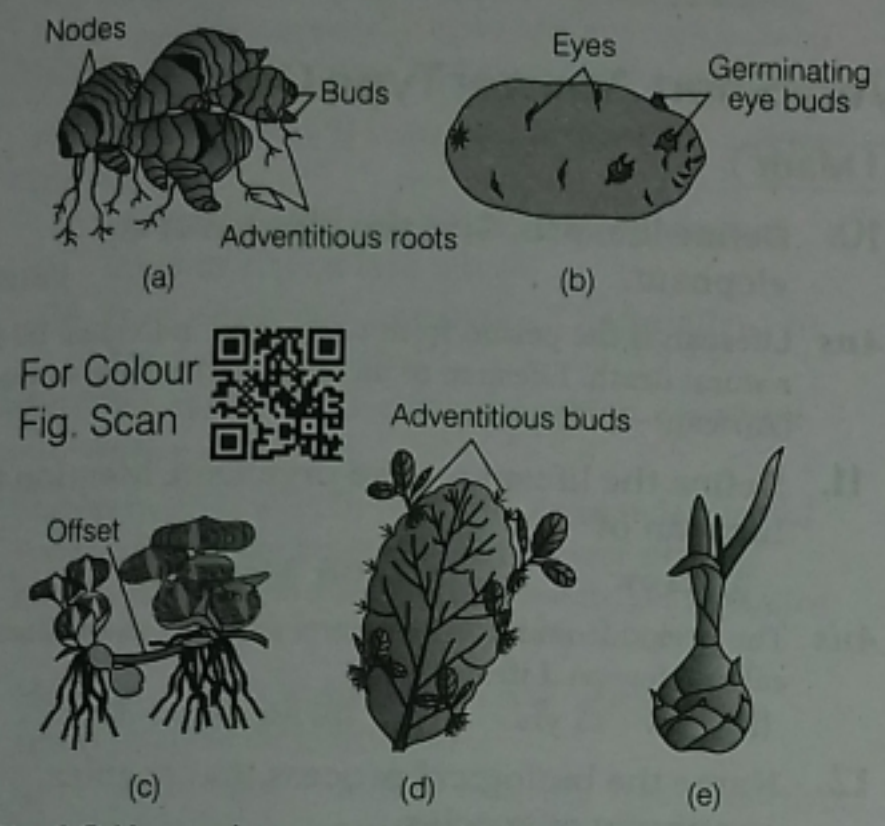


Fig. 1.9 Vegetative propagules in angiosperms
(a) Rhizomes of ginger, (b) Potato tuber
(c) Offset of *Eichhornia*, (d) Leaf buds of *Bryophyllum*
(e) Bulbil of *Agave*

4. **Aerial stems** Aerial modified stems of cacti develop new plants when the stem segments fall on the ground. These act as a means of vegetative propagation, e.g. *Opuntia*, etc.
5. **Leaves** Some plants develop adventitious buds on their leaves which get detached and develop into new plants, e.g. *Bryophyllum*, *Kalanchoe*, *Begonia*, etc. This ability is fully exploited for commercial benefits by farmers.
6. **Bulbils** These are fleshy buds produced in the axil of foliage leaves in place of axillary buds. They grow to form new plants when they shed/fall on the ground, e.g. *Agave, Oxalis, Allium sativum,* lily, etc.

The new plantlets in the plants like potato, sugarcane, banana, *Dahlia*, ginger, etc., arise invariably from the **nodes** present in the modified stems of these plants. When these nodes come in contact with damp soil or water, they produce roots and new plants because of the meristematic cells present in them.

Artificial Vegetative Propagation

Vegetative propagation can also be done artificially and, the man-made methods for vegetative propagation are called **artificial methods** of vegetative propagation. They include

1. **Cutting** In this method, a small piece of any plant organ (stem, root or leaf) is used for propagation, e.g. leaves (*Bryophyllum*), roots (tamarind), stems (sugarcane, grapes, rose and *Bougainvillea*).
2. **Layering** In this method, roots are artificially induced on branches of stem before they are detached from the parent plant, e.g. jasmine, grapevine, litchi, orange, etc.
3. **Grafting** In this method, parts of the two plants are joined in such a way that they grow as one plant. The rooted supporting portion of one plant called **stock**, is joined with the twig of another plant called **scion**, e.g. rose, apple, plum, peach, mango, etc.
4. **Micropropagation** This method includes propagation of plants by culturing the cells, tissues and organs in laboratory which is called **tissue culture**. Initially, this forms an undifferentiated mass of cells called **callus**. Later on, this callus differentiates to produce many small plantlets.

TOPIC 02

Sexual Reproduction in Higher Organisms

Sexual reproduction requires more time and energy, but higher organisms have resorted to sexual mode of reproduction inspite of its complexity. It is because this mode of reproduction helps in introducing new variations in progenies through the combination of the gametes from two different individuals, i.e. male and female. Sexual reproduction is also known as **syngenesis** or **amphimixis**.

Sexual Reproduction

The mode of reproduction which involves the formation of male and female gametes either by same individual or by different individuals of opposite sex is known as **sexual reproduction**. These gametes fuse to form a new cell called **zygote**, which grows and develops into a new individual.

As fusion of male and female gametes is involved, the offsprings produced are neither identical to the parents nor amongst themselves. In comparison to asexual reproduction, it is an elaborate, complex and slow process. However, it has certain advantages over asexual reproduction such as

(i) Genetic recombination in offsprings causes variations.

(ii) It plays an important role in evolution.

- Sexual reproduction is exhibited by multicellular organisms, i.e. all flowering plants and most of the animals. Before an organism starts to reproduce sexually, it has to attain a certain level of growth and maturity.

Phases of Growth

- The period during which an organism grows to attain the sexual maturity is called **juvenile phase** (in animals) and **vegetative phase** (in plants).
- This phase is followed by another phase when the organism starts reproducing sexually. It is called **reproductive phase**. The end of reproductive phase is marked by the onset of another phase called **senescent phase** (old age) which is the last phase in the life cycle, after which, the organism dies.
- In both plants and animals, the transitions between these three phases are regulated by hormones. Interaction between hormones and certain environmental factors regulate the reproductive processes and the associated behavioural expressions of organisms.

Sexual Reproduction in Plants

(i) Annuals and biennial plants exhibit evident vegetative, reproductive and senescent phases of growth.

(ii) In perennials, these phases are not defined clearly.

(iii) Some plants show unusual behaviour for flowering, e.g. *Strobilanthes kunthiana* (Neelakurinji) plant flowers once in 12 years, whereas bamboo plants flower only once in their lifetime generally after 50-100 years.

Note Between September-October 2006, Neelakurinji plants mass flowering transformed large tracks of hilly areas in Kerala, Karnataka and Tamil Nadu into blue stretches and attracted a large number of tourists.

Sexuality in Plants

In some plants and fungi, male and female reproductive structures may be present on the same plant, such plants are called **homothallic** or **monoecious**, e.g. *Chara*, *Cucurbita*, coconut palm, etc.

While in some lower plants, male and female reproductive structures may be present on different plants. These plants are known as **heterothallic** or **dioecious**, e.g. *Marchantia*, date palm, etc.

In angiosperms, flower is the reproductive part of the plant. In some angiosperms like mustard, China rose, pea, etc. each flower contains both stamens and pistil. Such type of flowers are called **bisexual flowers**.

In contrast to above, in some angiosperms such as papaya, watermelon, sunflower, rice, wheat, etc. flowers contain either stamen or pistil. Such type of flowers are called **unisexual flowers**.

Unisexual flowers with stamen (staminate flowers) are male flowers, while flowers with pistil (pistillate flowers) are female flowers.

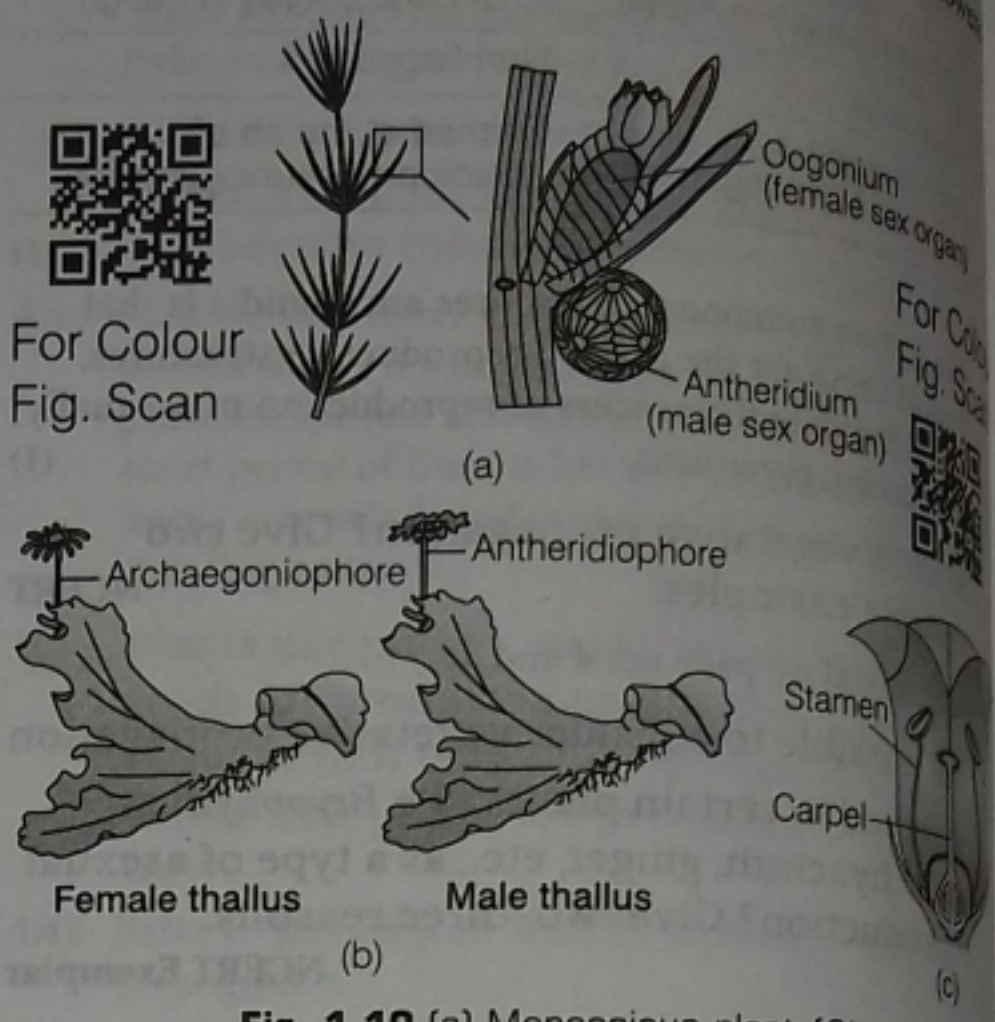


Fig. 1.10 (a) Monoecious plant (*Chara*) (b) Dioecious plant (*Marchantia*) (c) Bisexual flower (Sweet potato)

Sexual Reproduction in Animals

(i) Some animals remain reproductively active throughout their reproductive phase, such animals are called **continuous breeders**, e.g. humans.

(ii) On the other hand, there are some animals, which become reproductively active only during favourable seasons in their reproductive phase, such animals are called **seasonal breeders**, e.g. dogs, birds, frogs, lizards, etc.

(iii) In animals, morphological and physiological changes occur prior to and post-reproductive phase. During the reproductive phase in mammals, the activities of ovaries, accessory ducts and hormones exhibit cyclic changes as follows

(a) In the non-primate animals such as dogs, tigers, cows, rats, sheep, deers, etc. these cyclic changes are called **oestrous cycle**.

(b) In the primates such as monkeys, apes and humans, etc. these cyclic changes are called **menstrual cycle**.

Sexuality in Animals

On the basis of sexuality, animals are divided into two categories, i.e. bisexual (hermaphrodite) and unisexual animals.

1. **Bisexual** They possess both male and female reproductive organs in the same individual, i.e. earthworms, tapeworms, leech, sponges, etc.

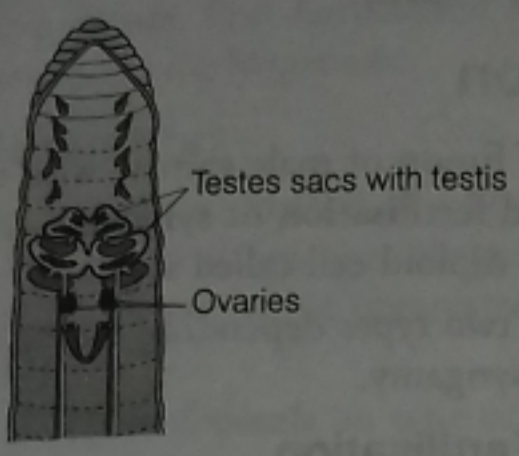


Fig. 1.11 Bisexual animal (earthworm)

2. **Unisexual** Both the sexes are separate with distinct male and female individuals, e.g. cockroach, dog, etc.

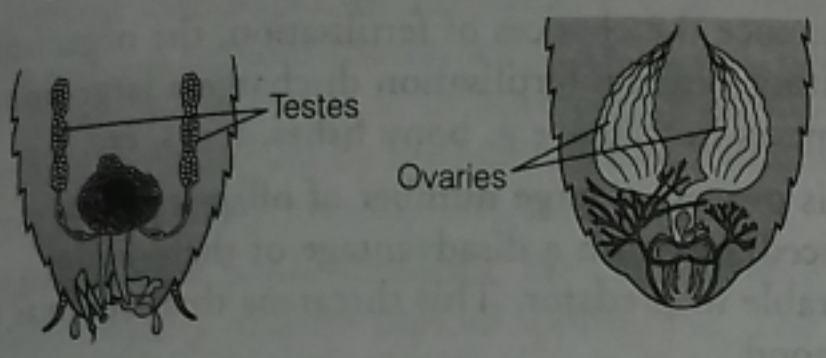


Fig. 1.12 Unisexual animal (cockroach)

Differences between asexual and sexual reproduction

Asexual reproduction	Sexual reproduction
It is always uniparental and does not involve gamete formation.	It is generally biparental and always involves the formation and fusion of gametes.
It involves only mitotic cell division.	It involves meiotic division during gamete formation and mitotic division during the development of zygote.
It does not contribute to evolution.	It contributes to evolution by introducing variations in the offsprings.
Daughter individuals are genetically identical to parent and to each other.	Daughter individuals are genetically different from their parent and also from each other.
It causes rapid increase in population size.	It causes slow increase in population size.

Events in Sexual Reproduction

The sequential events that take place during sexual reproduction can be grouped into three categories, i.e. **pre-fertilisation, fertilisation** and **post-fertilisation.**

Pre-Fertilisation Events

All the events of sexual reproduction that take place before the fusion of gametes are included in this category Two main pre-fertilisation events are given below

Gametogenesis

- The process of formation of male and female gametes (haploid cells) is called **gametogenesis.** When the two gametes are similar in appearance and it is not possible to differentiate them into male and female gametes, the are called **homogametes** or **isogametes**, e.g. in some algae.
- If the male and female gametes are morphologically dissimilar, they are called **heterogametes**. Among heterogametes, the male reproductive unit is called **antherozoid** or **sperm** and the female reproductive unit is known as **egg** or **ovum** [fig. 1.13 (b, c)].
- **Cell division during gamete formation** Organisms suc as monerans, fungi, algae and bryophytes have **haploid** parental body, they produce gametes by mitotic divisio whereas, organisms belonging to pteridophytes, gymnosperms, angiosperms and most of the animals including human beings have **diploid** parental body an gametes are thus formed by meiosis. In such organisms specialised cells called **meiocytes** (gamete mother cell) are present, which take part in the production of gametes.

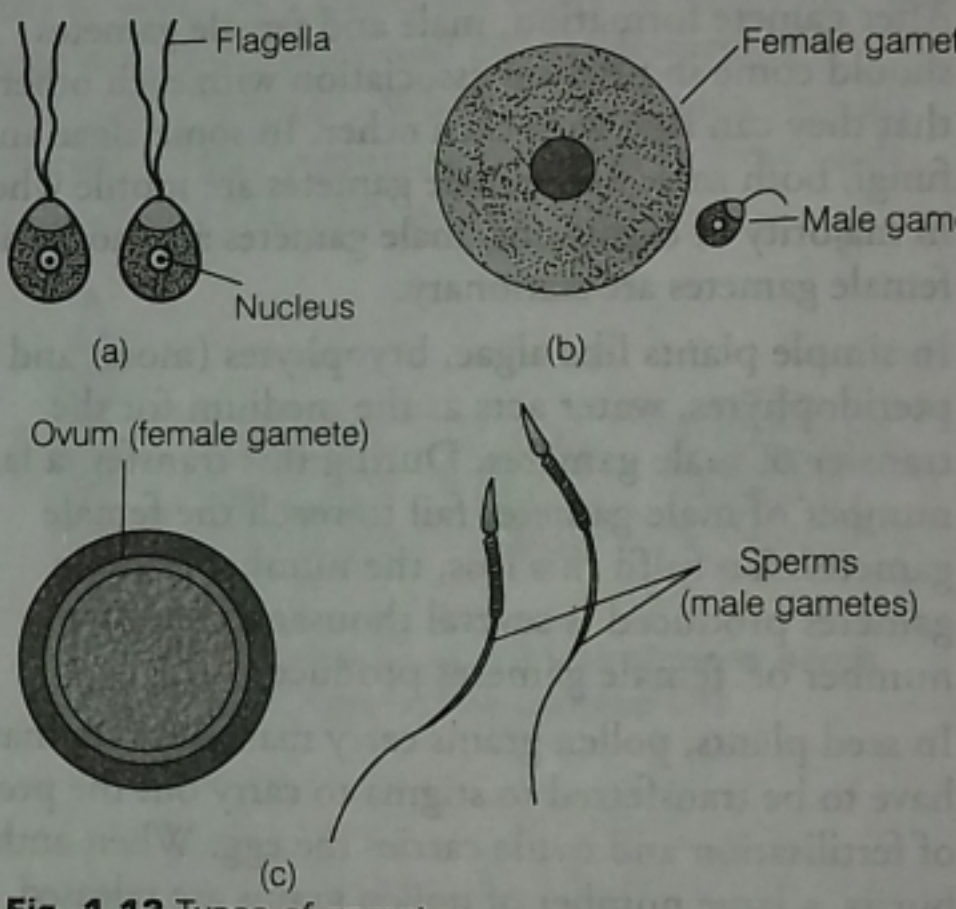


Fig. 1.13 Types of gametes
(a) Isogametes of *Cladophora* (an alga)
(b) Heterogametes of *Fucus* (an alga)
(c) Heterogametes of *Homo sapiens* (human)

At the time of gamete formation, meiocytes undergo meiotic division. As a result of meiotic division, the number of chromosomes in the daughter cells, i.e. in the gametes reduces to half and thus, from the **diploid** meiocytes, **haploid** gametes are formed.

Chromosome numbers in meiocytes (diploid, $2n$) and gametes (haploid, n) of some organisms are given below

Name of organism	Chromosome number in meiocyte ($2n$)	Chromosome number in gamete (n)
Ophioglossum (a fern)	1260	630
Apple	34	17
Rice	24	12
Maize	20	10
Potato	48	24
Onion	16	8
Human beings	46	23
Housefly	12	6
Rat	42	21
Dog	78	39
Cat	38	19
Fruitfly	8	4
Butterfly	380	190

Gamete Transfer

- After gamete formation, male and female gametes should come in physical association with each other, so that they can fuse with each other. In some algae and fungi, both male and female gametes are motile whereas in majority of organisms, male gametes are motile and female gametes are stationary.
- In simple plants like algae, bryophytes (moss) and pteridophytes, water acts as the medium for the transfer of male gametes. During this transfer, a large number of male gametes fail to reach the female gametes. To fulfil this loss, the number of male gametes produced is several thousand times the number of female gametes produced.
- In seed plants, pollen grains carry male gametes that have to be transferred to stigma to carry out the process of fertilisation and ovule carries the egg. When anther bursts, a large number of pollen grains are released.
- These pollen grains easily get transferred in bisexual plants like peas by self-pollination. However, in cross-pollinating plants (including dioecious plants), help of an agent (e.g. wind, water, insects) is required for transfer of pollen grains to the stigma of the pistil.

This transfer of pollen grains from anther to the ... called **pollination**. In unisexual animals, organ... evolve special mechanism for gamete transfer (e.g. copulatory organs).

Fertilisation

The process of fusion of male gamete with the ... gamete is called **fertilisation** or **syngamy**. It resul... formation of a diploid cell called **zygote**.

It is mainly of two types depending on the site of occurrence of syngamy.

1. External Fertilisation

In majority of the aquatic organisms, e.g. algae, ... in amphibians, the process of fertilisation takes p... outside the body of the organism, i.e. in water. T... of gametic fusion is called **external fertilisation**.

To enhance the chances of fertilisation, the orga... exhibiting external fertilisation discharge a large ... of gametes in water, e.g. bony fishes, frogs, etc.

By this process, a large number of offsprings are produced, but with a disadvantage of them being vulnerable to predator. This threatens their survi... adulthood.

2. Internal Fertilisation

In most of the terrestrial organisms, e.g. fungi, ... animals (reptiles, birds and mammals) and major... plants such as bryophytes, pteridophytes, gymnos... and angiosperms, the process of fertilisation take... inside the body of the organism. This type of ga... fusion is called **internal fertilisation**.

In the organisms exhibiting internal fertilisation, **non-motile** egg is formed inside the female body ... fuses with the male gamete that is **motile**. The nu... ova produced are less, but a large number of male gametes are formed, as many of them fail to reach ova. However, in seed plants, the pollen tubes he... non-motile male gametes to reach the female game...

- In honeybees, an interesting phenomenon is seen ... fertilised eggs (zygote) give rise to queens and wor... bees (both female) and unfertilised eggs (ova) dev... into drones (males).
- **Parthenocarpy** is the production of fruit without fertilisation of ovules, thus resulting in seedless fr... may occur naturally or can be induced artificially.

Note In some organisms like rotifers, honeybees, birds (turke... even in some lizards, the female gametes (ovum) form new organism without fertilisation. This phenomenon is called **parthenogenesis**. In animals, morphological and physiologic... changes occur prior to and post reproductive phase.