

Lifespan is the period from birth to the natural death of an organism. It may vary from less than a day to more than 400 yrs (in case of some plants). Whatever be the lifespan, death of every individual is a certainty, i.e. no individual is immortal, except a few single-celled organisms.

Reproduction

Reproduction is a biological process of continuity of a race in which the grown up individuals give rise to offsprings similar to them.

Reproduction is an essential phenomenon as it:

- (i) enables continuity of the species.
- (ii) maintains life on the earth.
- (iii) create variations among population.

The process of reproduction varies in different organisms, depending on their habitat, internal physiology and several other factors.

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Types of Reproduction

Types of reproduction based on whether there is participation of one or two organisms in the process, reproduction can be of following two types:

- (i) Asexual reproduction
- (ii) Sexual reproduction

[TOPIC 1] Asexual Reproduction

A single parent is capable of producing offsprings. Thus, the offsprings, which are produced by asexual reproduction are genetically and morphologically identical to one another and to their parent. These are often referred to as **clone**. The unit of reproduction is commonly formed from the somatic cells of the parent. Meiosis does not occur in asexual reproduction.

Asexual reproduction is common among single-celled organisms and in plants and animals with relatively simpler body organisation. Cell division itself is a mode of reproduction in protists, e.g. *Amoeba* and monerans. In bacteria, the parent cell divide into two to give rise to new individuals.

Types of asexual reproduction are as given below:

Fission

Fission can be further classified as:

- (i) **Binary fission** The body of an individual divides into two equal halves.

It can be of following types:

- (a) **Simple binary fission** When division occurs in any plane, but it is always right angle to the elongated dividing nucleus, e.g. *Amoeba*.
- (b) **Longitudinal binary fission** When division occurs along the longitudinal axis, e.g. *Euglena*, *Vorticella*.

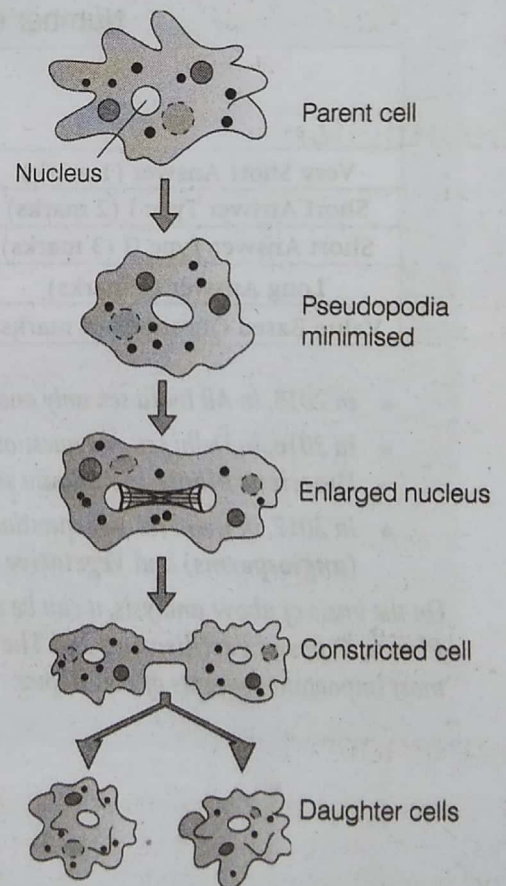


Figure 1.1 Binary fission in *Amoeba*

- (c) **Oblique binary fission** When division occurs at an angle to the transverse axis, e.g. *Ceratium*, *Gonyaulax*.
- (d) **Transverse binary fission** When division occurs along the transverse axis of the individual, e.g. *Paramecium*, diatoms, bacteria, *Planaria*.
- (ii) **Multiple fission** The division of the parent body into many daughter organisms, e.g. *Plasmodium*, *Monocystis* (all protozoan).

Budding

Budding, (torulation) an outgrowth or bud develops, grows, constricts at the base and separates from the parent body. e.g. yeast and *Hydra*. The complex budded condition is called **torula stage**.

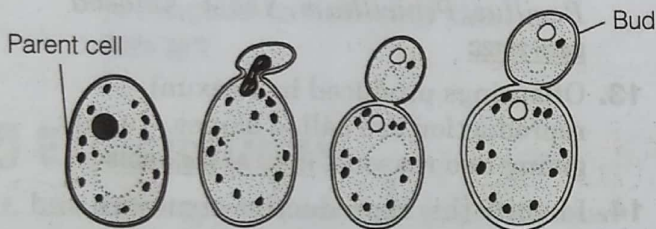


Figure 1.2 Budding in yeast

Sporulation

Sporulation occurs by tiny, single-celled, thin-walled spores that are extremely resistant to environmental extremes. The spores form new individuals. These are most commonly formed in Monera, Protista, Fungi and Algae.

Spores formed can be of following main types:

- Pseudopodiospore (with fine pseudopodia) – *Amoeba*
- Zoospores (motile and flagellated) – *Chlamydomonas* and *Ulothrix*
- Conidia (non-motile) – *Penicillium*
- Sporangiospores (non-motile) – *Rhizopus*
- Gemmules (internal buds) – Sponges

Fragmentation

Fragmentation occurs by breaking of the parent body into two or more parts, each of which grows to form an independent individual, e.g. algae like *Spirogyra* and bryophytes such as *Marchantia*, *Riccia*, etc.

Regeneration

Regeneration is a type of asexual reproduction in which the missing part of the organism is repaired by the proliferation of cells, e.g. *Hydra*, *Planaria* and sponges.

Vegetative propagation

Vegetative propagation is the formation of a new plant from vegetative parts like root, stem, leaf, etc., naturally. The units of vegetative propagation such as runner, rhizome, sucker, tuber, offset, bulb all have capability to give rise to new offsprings. These structures are known as **vegetative propagules**. Some artificial methods of vegetative propagation are also developed by the farmers like cutting, layering, grafting, etc.

Table 1.1 Some examples of natural method of vegetative propagation are:

Vegetative part	Example
Roots	<i>Dahlia</i> , <i>Asparagus</i> , <i>Dalbergia</i> , guava and tapioca
Stems	<ul style="list-style-type: none"> • Tubers: Potato and artichoke • Bulbs: Garlic and onion • Rhizome: Ginger, turmeric, banana and <i>Dryopteris</i> • Corms: <i>Colocasia</i>, <i>Crocus</i> and <i>Amorphophallus</i> • Suckers: Mint and <i>Chrysanthemum</i> • Runners: <i>Oxalis</i> and <i>Centella</i> • Stolons: Jasmine • Offsets: <i>Pistia</i> and <i>Eichhornia</i>
Leaves	<i>Bryophyllum</i> , <i>Begonia</i> , <i>Kalanchoe</i> and walking fern
Bulbils	<i>Agave</i> , lily and <i>Dioscorea</i>
Turions (fleshy buds in aquatic plants)	<i>Potamogeton</i> and <i>Utricularia</i>

Water hyacinth (scourage of the water bodies or Terror of Bengal) propagates very quickly by vegetative mode and drains out dissolved O₂ from water bodies.

[TOPIC 2] Sexual Reproduction

In sexual reproduction, two parents of opposite sex participate along with fusion of male and female gametes. All organisms have to reach a certain stage of growth and maturity in their life cycle before they reproduce sexually. Life cycle of an organism is divided into the following three phases:

- (i) **Juvenile or vegetative phase** – Pre-reproductive period
- (ii) **Reproductive phase** – Reproductive period
- (iii) **Senescent phase** – End of reproductive period leading to ageing.

Reproduction is a seasonal phenomenon in some organisms.

- (i) Based on the seasonality in reproduction in majority of plants, following categories can be made:
 - (a) **Monocarpic plants** Flowering occurs once in their life cycle, bear fruits and die, e.g. annuals like rice, wheat; biennials like radish, henbane, etc.
 - (b) **Polycarpic plants** Flowering occurs every year in a particular season after reaching maturity, e.g. mango, apple, orange, etc. Bamboo species flower only once in their lifetime generally after 100 years. These produce large number of fruits and ultimately die. Similarly, *Strobilanthes kunthiana* (neelakuranji), flowers (blue in color) blooms once in every 12 years.
- (ii) Similarly, in animals, the categories are:
 - (a) **Seasonal breeders** Breed at a particular time of the year, e.g. frogs, lizards, birds, etc.
 - (b) **Continuous breeders** Reproduce throughout their lifespan of sexual maturity, e.g. cattle, poultry, rabbit, etc.
- (iii) During reproductive phase in mammals, many cyclic changes occur in the reproductive system of females, i.e.
 - (a) In **non-primate mammals** such as cow, sheep, rat, deer, dog, tiger, etc., the cyclic changes occurring during reproduction are termed **oestrus cycle**.
 - (b) In **primate mammals**, such as monkeys, apes and humans, the cyclic changes occurring during reproduction are termed as **menstrual cycle**.

2.1 Events in Sexual Reproduction

The events of sexual reproduction occur in the following three stages:

1. Pre-fertilisation

The two main pre-fertilisation events are as follows:

Gametogenesis

It is the formation of male and female gametes. Types of gametes are:

- (i) **Homogametes or isogametes** Gametes, which are not differentiated as male and female gametes, e.g. algae such as *Ulothrix*.
- (ii) **Heterogametes** Gametes, which are morphologically distinct, e.g. gametes in human, i.e. sperm (male) and ovum (female).

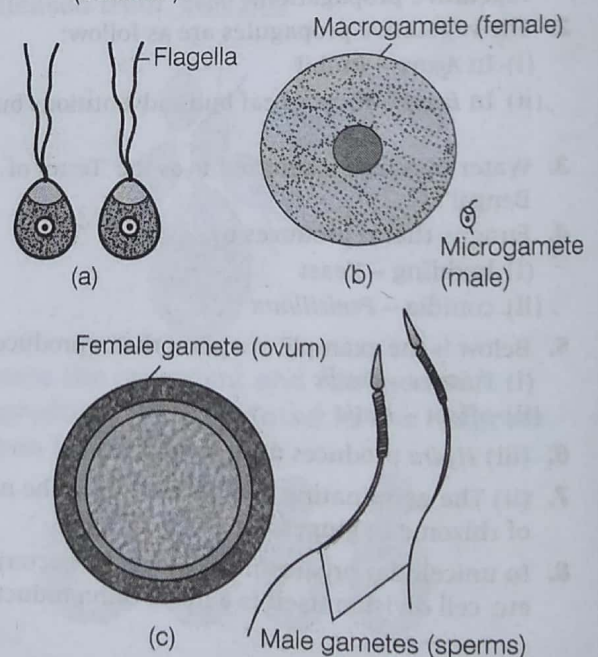


Figure 1.3 Types of gametes

- (a) Isogametes of *Cladophora* (an alga)
- (b) Heterogametes of *Fucus* (an alga)
- (c) Heterogametes of *Homo sapiens* (human beings)

On the basis of gametes, sexuality in organisms can be classified as follows:

Sexuality in Plants

- (i) **Homothallic or monoecious plants** Both male and female flowers are present on same plant body (bisexual condition), e.g. in several fungi and plants like maize, cucurbits and coconuts.
- (ii) **Heterothallic or dioecious plants** Male and female flowers are present on separate plant body (unisexual condition), e.g. papaya and date palm. In flowering plants, the unisexual male flower is staminate, while female is pistillate.

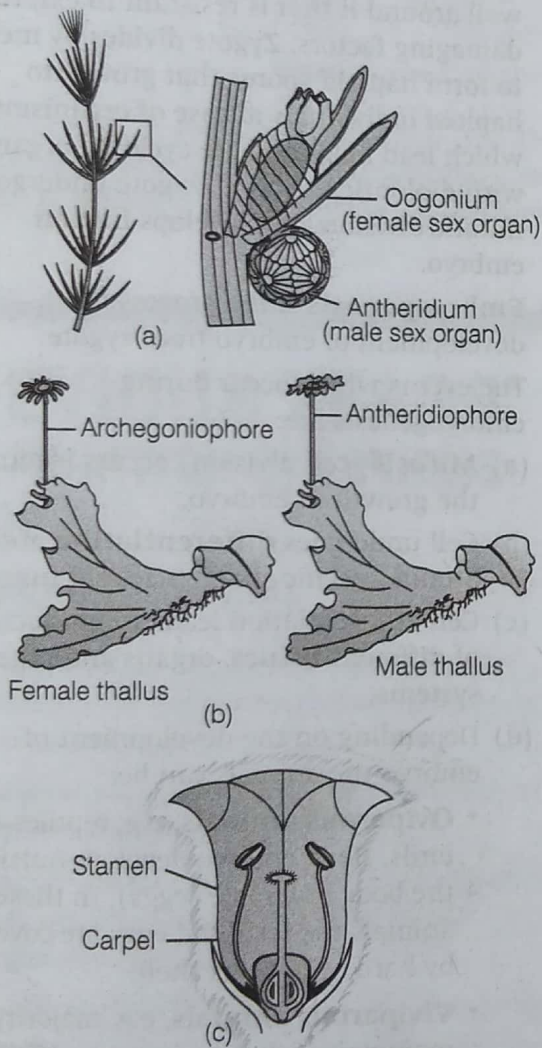


Figure 1.4 Diversity of sexuality in plants
 (a) Monoecious plant (*Chara*)
 (b) Dioecious plant (*Marchantia*)
 (c) Bisexual flower (sweet potato)

Sexuality in Animals

- (i) **Bisexual animals** have both male and female organs in single individual, e.g. earthworm, sponge, leech, tapeworm, etc. These are also called as hermaphrodites.
- (ii) **Unisexual animals** have male and female organs in different individuals, e.g. cockroach, human, dog, etc.

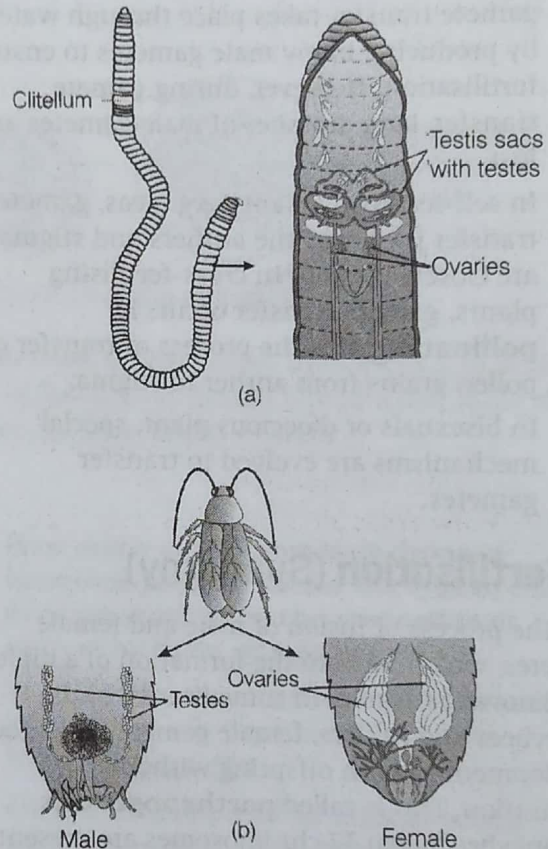


Figure 1.5 Diversity of sexuality in organisms
 (a) Bisexual animal (earthworm) (b) Unisexual animal (cockroach)

Cell Division during Gamete Formation

- (i) Gametes are always haploid.
- (ii) The organisms belonging to Monera, fungi, algae and bryophytes have **haploid** plant body. These organisms produce gametes by mitotic division.
- (iii) In pteridophytes, gymnosperms, angiosperms and most of the animals including humans, the parental body is **diploid**. In these organisms, specialised cells called meiocytes or gamete mother cells undergo meiosis that results in formation of haploid gametes.

Gamete Transfer

It occurs in various ways in different organisms:

- (i) In most organisms, male gamete is motile and female gamete is non-motile.
- (ii) Both gametes are motile in few fungi and algae. In bryophytes and pteridophytes male gametes are known as antherozoid.
- (iii) In algae, bryophytes and pteridophytes, gamete transfer takes place through water by producing many male gametes to ensure fertilisation. However, during gamete transfer, large number of male gametes are lost.
- (iv) In self-fertilising plants, e.g. peas, gamete transfer is easy as the anthers and stigma are closely located. In cross-fertilising plants, gamete transfer occurs by **pollination**. It is the process of transfer of pollen grains from anther to stigma.
- (v) In bisexuals or dioecious plant, special mechanisms are evolved to transfer gametes.

2. Fertilisation (Syngamy)

It is the process of fusion of male and female gametes, which leads to the formation of a diploid cell, known as zygote. In some lizards, birds, honeybees and rotifers, female gamete undergoes development to form offspring without fertilisation. This is called **parthenogenesis**. In honeybee queen 32 chromosomes are present. During the development of eggs within a queen, a diploid cell with 32 chromosomes divides to generate haploid cells called gamete with 16 chromosomes. Now this haploid egg with 16 chromosomes forms new offspring (known as Drone) without fertilisation. Depending upon, where does the syngamy occurs, fertilisation may be of two types:

- (i) **External fertilisation** It is the fusion of gametes that takes place outside the body of an organism in external medium such as water, e.g. bony fishes, frogs, etc. A large number of gametes are released in the surrounding medium by such animals.

- (ii) **Internal fertilisation** It is the fusion of gametes that takes place inside the body, e.g. fungi, higher animals such as birds, mammals and majority of plants. The number of ova produced is less, but a large number of male gametes are formed, as many of them fail to reach the ova.

3. Post-fertilisation Events

These event occur after zygote formation.

- (i) **Zygote** is the beginning of new life. It is always diploid and ensures the continuity of race from generation to generation. Organism such as fungi, develops a thick wall around it that is resistant to external damaging factors. Zygote divides by meiosis to form haploid spores that grow into haploid individuals in case of organisms which lead haplontic life cycle. In organisms with diplontic life cycle, zygote undergoes mitotic division and develops into an embryo.
- (ii) **Embryogenesis** is the process of development of embryo from zygote. The events which occur during embryogenesis are:
 - (a) **Mitosis** (cell division) occurs leading to the growth of embryo.
 - (b) Cell undergoes **differentiation** and attains specific shape, size and function.
 - (c) Cell differentiation leads to production of different tissues, organs and organ systems.
 - (d) Depending on the development of embryo the animals can be:
 - **Oviparous animals**, e.g. reptiles and birds. Here, embryo develops outside the body of female (eggs). In these animals the fertilised eggs are covered by hard calcareous shell.
 - **Viviparous animals**, e.g. majority of mammals including humans. Here, embryo develops inside the body of female.

(e) The post-fertilisation events that occur in flowering plants are:

- **Sepals, petals** and **stamens** wither and shed off.
- **Pistil** remains attached to the plant.
- **Zygote** develops into embryo and the ovules develop into seed.
- **Ovary** develops into the fruit.
- **Pericarp** is produced as the wall of ovary. Seeds disperse by different agents and germinate into new plants after getting suitable conditions.

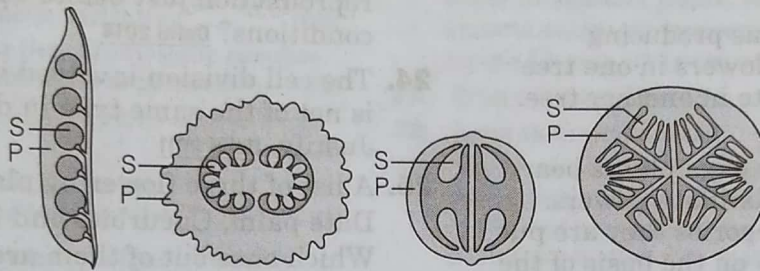


Figure 1.6 Few fruits showing seeds (S) and protective pericarp (P)

Organisms such as aphids, slime moulds, sea-anemones and many plants switch from asexual to sexual mode of reproduction, when environmental conditions are unfavourable. Sexual reproduction leads to variation in offsprings, thus providing a mechanism for selective adaptations to occur.