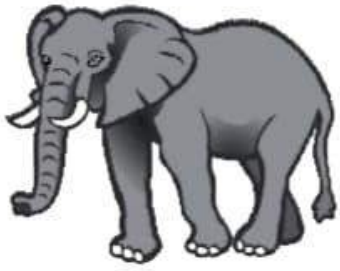
EDUCATALYSTS

Class(12th)

Introduction to Reproduction in organisms

Life Span

- The period from birth to the natural death of an organism represents its **life span**.
- It varies with organisms.
- It may be as short as a few days or as long as a few thousand years.
- Life spans of organisms are not necessarily correlated with their sizes
- The sizes of crows (15 years) and parrots (140 years) are not very different yet their life spans show a wide difference.
- Similarly, a mango tree (200 years) has a much shorter life span as compared to a peepal tree (2500 years).
- Whatever be the life span, death of every individual organism is a certainty, i.e., no individual is immortal, except single-celled organisms.



Elephant (60-90 years)

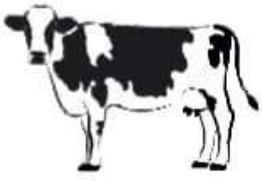
Rose (5-7 years)

Dog (25-30 years)

Butterfly (1-2 weeks)

Crow (15 years)

Banana tree (25 years)



Cow (20-25 years)

Parrot (140 years)

Crocodile (60 years)

Horse (60 years)

Fruit fly (2 weeks)

Rice plant (3-4 months)

Tortoise (100-150 years)

Banyan tree (~ 180 years)

Fig.: Life span of some organisms

Reproduction

- Reproduction is defined as a **biological process** by which an organism gives rise to young ones (offsprings) similar to itself.
- The offsprings grow, mature and in turn produce new offsprings. Thus, there is a cycle of birth, growth and death.
- Reproduction enables the continuity of the species generation after generation. The genetic variation is inherited during reproduction.
- Each organism has evolved its own mechanism to multiply and produce offspring.
- The organism's habitat, its internal physiology and several other factors are collectively responsible for how it reproduces.

Basic features of reproduction:

All organisms reproduce. Modes of reproduction vary in different organisms. However, all modes have certain common basic features. These are:

- Replication of DNA. This is the molecular basis of reproduction.
- Cell division, only mitotic, or both mitotic and meiotic. This is cytological basis of reproduction.
- Formation of reproductive bodies or units.
- Development of reproductive bodies into offspring.

- Reproduction can be categorized into two types:
  1. Asexual reproduction 2. Sexual reproduction

Asexual Reproduction

- When offspring is produced by a single parent with or without the involvement of gamete formation, the reproduction is asexual.
- In this method, a single individual (parent) is capable of producing offspring.
- The offsprings produced are identical to each another as well as to the parent.

— *KEY NOTE* —

- **A population of morphologically and genetically similar individuals which are obtained from the parent individual is called clone. Each member of clone is termed as ramet.**
- **Unicelluar organisms do not show senescence nor natural death**

- It is common among single-celled organisms, and in plants and animals with relatively simple organisations.
- It is relatively simple and fast as compared sexual reproduction.
- In unicellular 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

1. Asexual Reproduction In Animals and Microbes

The most common modes of asexual reproduction are as follows:

(i) Fission

Binary Fission

- Many single-celled organisms reproduce by binary fission, where a cell divides into two halves and each rapidly grows into an adult (e.g., *Amoeba*, *Paramecium*).
- This method is common in Protista and Monerans.
- It normally takes places under favourable conditions.
- On the basis of plane of division, binary fission is of four types
  - **(a) Simple binary fission:** Division can take place through any plane. E.g., *Amoeba*.

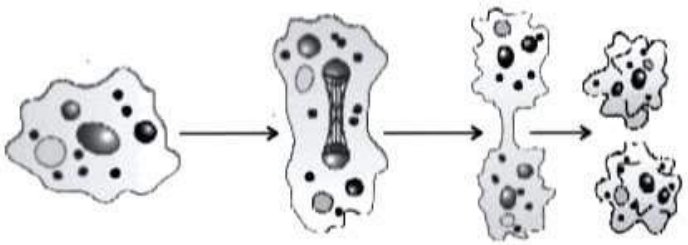
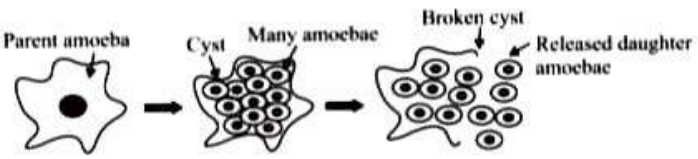


Fig.: Simple binary fission in *Amoeba*

  - **(b) Transverse binary fission:** The plane of division runs along the transverse axis of the individual. E.g., *Paramoecium*, Diatoms and Bacteria.
  - **(c) Longitudinal binary fission:** The plane of fission passes along the longitudinal axis of the individual. E.g., *Euglena* and *Vorticella*.
  - **(d) Oblique binary fission:** The individual is divide obliquely. E.g., *Opalina*, *Ceratium* and *Gonyulax*.
- Binary fission involves mitosis only and consequently, the resultant offsprings are genetically identical to the parent and each other.
- **Note:** Cell division during binary fission can be mitosis (in eukaryotes) or amitosis (in prokaryotes)

Multiple Fission

- Under unfavourable condition the Amoeba withdraws its pseudopodia and secretes a three-layered hard covering or cyst around itself. This phenomenon is termed as **encystation**.
- When favourable conditions return, the encysted Amoeba divides by multiple fission and produces many minute amoeba or pseudopodiospores; the cyst wall bursts out, and the spores are liberated in the surrounding medium to grow up into many amoebae. This phenomenon is known as **sporulation**.



(ii) Budding

- In this method, cells of some body parts undergo **repeated mitotic cell divisions** (unequal) that leads to the formation of small buds that remain attached initially to the parent, finally detached and mature into new cell. E.g., Yeast

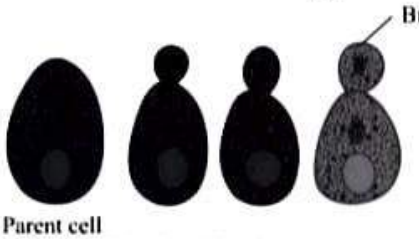


Fig: Budding in yeast

- Budding is of two types:
  - **(a) Exogenous or external budding:** Initially, a small outgrowth of the parent's body develops into a miniature individual. It then separates from the mother to lead a free life. This type of budding is recognised as exogenous budding. E.g., *Hydra*.
  - **(b) Endogenous or internal budding:** In fresh water sponges (e.g., *Spongilla*) and marine sponge (e.g., *Sycon*), the parent individual releases a specialised mass of cells enclosed in a common opaque envelope, called the **gemmule**, on germination. Each gemmule gives rise to an offspring. Gemmules are thought to be internal buds. This type of budding are recognised as endogenous budding. E.g., *Sycon* and *Spongilla*.

Binary Fission in *Amoeba*	Budding in *Yeast*
1. Equal cytokinesis	1. Unequal cytokinesis
2. Equal karyokinesis	2. Equal karyokinesis
3. Parent cell disappears (Parent cell loses its identity)	3. Parent cell remains intact (parent cell does not loses its identity)

(iii) Regeneration

- It is the ability of body cells to produce lost body parts or entire body
- It is the ability of body cells to regenerate the lost body parts.
- E.g., *Planaria*, *Hydra*, Starfish, etc.
- **Note:** *Planaria* shows true regeneration.

(iv) Fragmentation

- It is the breaking up of an animal's body into two or more pieces, each of which grows into a new individual, e.g., *Spirogyra*.
- It also occurs in the flatworm, *Microstomum*.

2. Asexual Reproduction In Plants

The common modes of asexual reproduction in plants are:

(i) Fission

- **Simplest** of all asexual methods.
- Commonly found in unicellular alage.
- In this process, the unicellular parent cell divides mitotically to form two daughter cells that are identical to each other as

(ii) Buds

- The division is **unequal** and small buds are produced that remain attached initially to the parent cell which eventually get separated and mature into a new organism.

  E.g., *Dictyota*, *Fucus*

(iii) Regeneration

- Due to mechanical pressure, the vegetative thallus or hyphae breaks down into small segments which are capable of growing into a new individuals. E.g., algae (*Ulothrix*, *Dedogonium*, *Spirogyra* and *Zygnema*) and fungi (e.g., *Mucor*, *Rhizophus*, and *Saprolegnia*.)

(iv) By means of special asexual reproductive structures

- Members of the Kingdom Fungi and simple plants such as algae reproduce through special asexual reproductive structures (asexual spores).
- Zoospores are most common asexual spores in algae, and they are flagellated (motile).
- Conidia are the most common asexual spores in fungi, and they are non-flagellated (non-motile)
- Other common asexual reproductive structures are:

Reproductive Structure	Organism
• Conidia	*Penicillium*
• Buds	*Hydra*
• Gemmules	Sponge
• Zoospores	*Chlamydomonas*

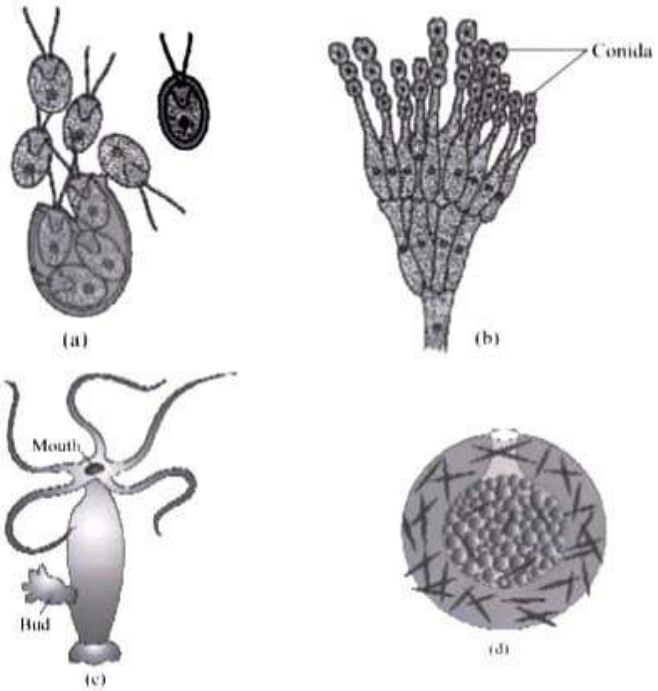


Fig.: Asexual reproductive structures: (a) Zoospores of *Chlamydomonas*; (b) Conidia of *Penicillium*; (c) Buds in

(v) Vegetative Propagation

- While in animals and other simple organisms the term **asexual** is used unambiguously, in plants, the term **vegetative** reproduction is frequently used.
- It is the development of new plants from vegetative parts like roots, stem, leaf, bulbils, turions, etc. The units or structures of vegetative propagation are called **vegetative propagules**.

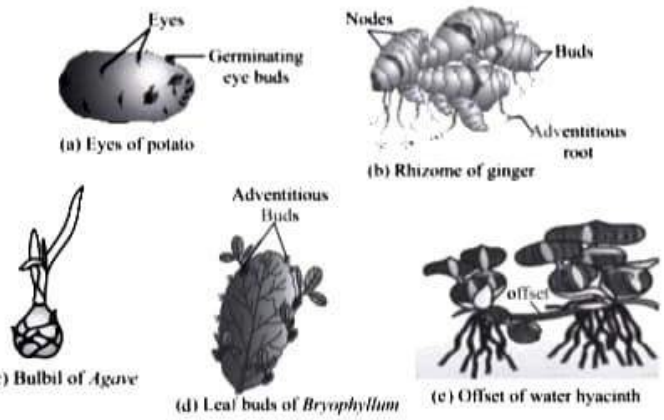


Fig.: Vegetative propagules in angiosperms (a) Eyes of potato; (b) Rhizome of ginger; (c) Bulbil of Agave; (d) Leaf buds of Bryophyllum; (e) Offset of water hyacinth

(a) By roots: Modified tuberous root of Sweet potato (*Ipomoea batatas*), *Asparagus*, *Tapioca*, Yam, *Dahlia* and *Tinospora* can be propagated vegetatively when planted in soil.
In some plants adventitious buds develop on the ordinary roots like *Dalbergia sisso*, *Populus*, Guava, *Murraya*, *Albizzia lebbek*, etc., which grow to form new plants.

(b) Through underground stem: In some plants underground stem act as vegetative propagule. These are:

- **Rhizomes** - *Typha*; *Canna*, Ginger, Turmeric, Lotus.
- **Corm** - *Gladiolus*, *Colocasia*, *Crocus*, *Amorphophallus*, *Alocasia*, etc.
- **Bulbs** - Onion, Garlic and Lilies
- **Tubers** - Potato, *Helianthus tuberosus*, etc., which grow to form a new plant.
- **Sucker** - Mint and *Chrysanthemum*.

(c) Creepers: In some plants, adventitious root are developed from the nodes and form an aerial shoots. It includes:

(i) Runners: *Cynodon*, *Oxalis* and *Centella*

(ii) Stolon: *Fragaria* (Strawberry) and *Vallisneria*

(iii) Offset: *Pistia*, *Eichhornia* (water hyacinth)

— *KEY NOTE* —

Terror of Bengal

The aquatic plant 'water hyacinth' is one of the most invasive weeds found growing wherever there is standing water. It drains oxygen from the water, which leads to death of fishes. This plant was introduced in India because of its beautiful flowers and shape of leaves. Since it can propagate vegetatively at a phenomenal rate and spread all over the water body in a short period of time, it is very

(d) By leaves: Some plants produce adventitious buds on their leaves, e.g., *Bryophyllum*, *Begonia*. These buds remains dormant, when the leaves attached with plants but after separation, when it comes in contact with moist soil develop new plantlets (buds) which form new plants.

Need to know:

- In *Kalanchoe* plant, whole portion of leaf blade regenerate a new plant.
- In some of the plants, fleshy axillary buds develop from axis of leaves are called bulbils. E.g., *Dioscorea*, *Oxalis*, *Dentaria*, *Globba*, *Agave*, *Lilium*.
- Adventitious buds arise from the notches present at margins of leaves of *Bryophyllum*. This **ability is fully exploited by gardeners** and farmers for commercial propagation of such plants.

Significance of Vegetative Reproduction

(i) Vegetative reproduction is an ideal method of reproduction to retain parental traits.

(ii) It is beneficial to raise crops like banana, sugarcane, potato, etc., that do not produce viable seeds.

(iii) Vegetative reproduction is useful in obtaining **disease-free** plants.

(iv) It eliminates the need for special mechanisms such as pollination.

Sexual Reproduction

- It is also known as amphimixis, syngenesis
- It involves formation of the male and female gametes, either by the same individual or by different individuals of the opposite sex.
- These gametes fuse to form the zygote which develops to form the new organism.
- It is an elaborate, complex and slow process as compared to asexual reproduction.
- A study of diverse organisms–plants, animals or fungi–show that though they differ so greatly in external morphology, internal structure and physiology, when it comes to sexual mode of reproduction, surprisingly, they share a similar pattern.

— *KEY NOTE* —

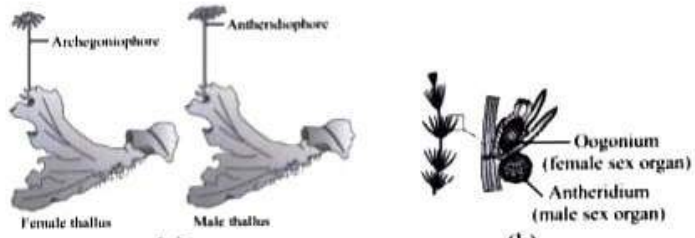
In sexual reproduction, of the fusion of male and female gametes, offspring are not identical to the parents or amongst themselves.

Life cycles of an organism

An organism has 3 life cycles. These are:

(i) Juvenile Phase:

- It is a pre-reproductive period in which an organism reach a certain stage of growth and sexual maturity.
- This phase is also known as vegetative



(a) (b)

Fig.: (a) Dioecious plant (*Marchantia*)
(b) Monoecious plant (Chara)

- In flowering plants, the unisexual male flower is called **staminate** flower and female flower is called **pistillate**.
- Earthworms, sponge, tapeworm and leech, typical examples of bisexual animals that possess both male and female reproductive organs, are **hermaphrodites**. Cockroach is an example of unisexual species.

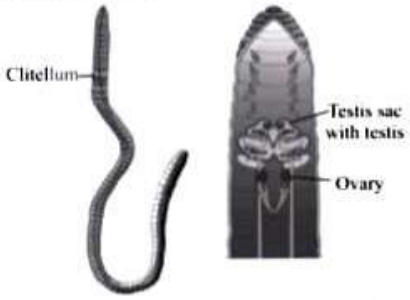


Fig.: Earthworm - Bisexual animal

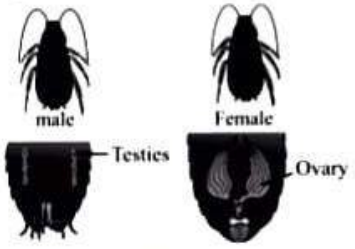


Fig.: Cockroach- Unisexual species

Cell Division During Gamete Formation

- Several organisms belonging to monera, fungi, algae and bryophytes have **haploid** plant body, but in organisms belonging to pteridophytes. gymnosperms, angiosperms and most of the animals including human beings, the parental body is **diploid**.
- Diploid parent have specialised cells called **meiocytes** (gamete mother cell) produces haploid gametes by meiotic division. The haploid parent produces gametes by **mitotic division**.

Table: Chromosome Numbers in Meiocytes (diploid, 2n) and Gametes (haploid, n) of some Organisms.

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

(ii) Gamete Transfer: After gametogenesis, male and female gametes are brought together to facilitate fusion.

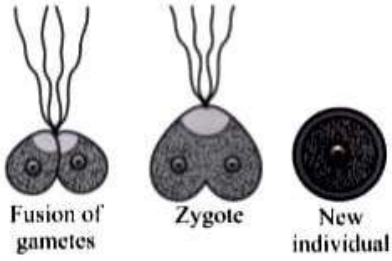


Fig.: Homogametic contact in alga

- In a majority of organisms, male gamete is motile and female gamete is stationary. They need a medium (water) through which the male gamete moves. e.g., bryophytes. But in other organisms, both gametes are motile. e.g., few fungi and algae
- A large number of the male gametes, however, fail to reach the female gametes. To compensate this loss or male gametes during transport, the number of male gametes produced is several thousand times the number of female gametes produced.
- In seed plants, pollen grains are the carriers of male gametes and ovule have the egg. Pollen grains produced in anthers therefore, have to be transferred to the stigma before it can lead to fertilisation.
- In **bisexual**, self-fertilising plants, e.g., peas, transfer of pollen grains to the stigma is relatively easy as anthers and stigma are located close to each other; pollen grains soon after they are shed, come in contact with the stigma. But in **cross pollinating plants**, pollination agency helps the transfer.
- Pollen grains germinate on the stigma and the pollen tubes carrying the male gamates reach the ovule and discharge male gametes near the egg.
- In diocious animals, since male and female gametes are formed in different individuals, the organism must evolve a special mechanism for gamete transfer.

— *KEY NOTE* —

Successful transfer and coming together of gametes is essential for the most critical event in sexual reproduction, the fertilisation.

- The most vital event of sexual reproduction is perhaps the fusion of gametes.
- It involves fusion of male and female gametes. This process called **syngamy** results in the formation of diploid zygote.
- In some organisms like rotifers, honeybees and even some lizards and bird (turkey), the female gamete undergoes development to form new organisms without fertilisation. This phenomenon is called **parthenogenesis**.

Site of fertilisation

- In most aquatic organisms, such as a majority of algae and fishes as well as amphibians, syngamy occurs in the external medium (water), i.e., outside the body of the organism. This type of gametic fusion is called **external fertilisation**.
- Organisms exhibiting external fertilisation show great synchrony between the sexes and release a large number of gametes into the surrounding medium (water) in order to enhance the chances of syngamy. This happens in the bony fishes and frogs where a large number of offspring are produced.

— *KEY NOTE* —

A major disadvantage of external fertilisation is that the offspring are extremely vulnerable to predators threatening their survival up to adulthood.

- In many terrestrial organisms, belonging to fungi, higher animals such as reptiles, birds, mammals and in a majority of plants (bryophytes, pteridophytes, gymnosperms and angiosperms), syngamy occurs inside the body of the organism, hence the process is called **internal fertilisation**.
- In all these organisms, egg is formed inside the female body where they fuse with male gamete.
- In organisms exhibiting internal fertilisation, the male gamete is motile and has to reach the egg in order to fuse with it.
- In seed plants, however, the non-motile male gametes are carried to female gamete by pollen tubes.

Table: Difference between external and internal fertilisation.

External Fertilisation	Internal Fertilisation
Fertilisation occurs outside the body (in water).	Fertilisation occurs inside the body of the organism.
Offspring are extremely vulnerable to predators threatening their survival up to adulthood.	Offspring are well protected and covered with calcareous shell in case of oviparous organisms.
Examples: Majority of algae, bony fishes and frog.	Examples: Terrestrial organisms (reptiles, birds, mammals) and in a majority of plants (except algae)

3. Post-fertilisation Events

- Events in sexual reproduction after the formation of zygote are called post-fertilisation events.

(i) Zygote

- Formation of the diploid zygote is universal in all sexually reproducing organisms.
- Zygote is a vital link between two successive generations.
- In organisms with external fertlilsation, zygote is formed in the external medium (usually water), whereas in those exhibiting internal fertilisation, zygote is formed inside the body of the organism.

Reasons behind shifting from asexual reproduction to sexual reproduction in lower organisms when the condition become unfavourable

- In many algae and fungi, the zygote secretes a thick wall that is resistant to desiccation and damage, which help organisms to tide over unfavourable conditions. During unfavourable conditions it undergoes a period of rest until a swing back to sustainability occurs.
- In addition variations found in offspring of sexual reproduction allow some individuals to be better suited for survival and provide a mechanism for selective advantage to occur.

— *KEY NOTE* —

Development of the zygote depends on

- **The type of life cycle of the organism**
- **The environment it is exposed to.**

- In fungi and algae, zygote develops a thick wall that is resistant to dessication and damage. It undergoes a period of rest before germination.
- In organisms with haplontic life cycle, zygote divides by meiosis to form haploid spores that grow into haploid individuals.

— *KEY NOTE* —

Zygote is the vital link that ensures continuity of species between organisms of one generation and the next.

(ii) Embryogenesis

- Embryogenesis refers to the process of development of embryo from the zygote.
- During embryogenesis, zygote undergoes cell division (mitosis) and cell differentiation. While cell divisions increase the number of cells in the developing embryo; cell differentiation helps groups of cells to undergo certain modifications to form specialised tissues and organs to form an organism.

On the basis where the development of zygote takes place, animals are categorised into two types:

Oviparous	Viviparous
The development of the zygote takes place outside the body of the female parent.	The development of the zygote takes place inside the body of the female parent.
These animals lay eggs. The fertilized eggs have a calcareous shell to protect them from harsh environment.	These animals give birth to young ones.

- In flowering plants, the zygote formed inside the ovule.
- After fertilisation on the sepals, petals and stamens of the flower wither and fall off. The pistil, however, remains attached to the plant.
- The zygote develops into embryo after which the ovule becomes the seed and ovary becomes the fruit.
- The fruit develops a thick wall called **pericarp** that is protective in function.
- After dispersal, seeds germinate under favourable conditions to produce new plants.

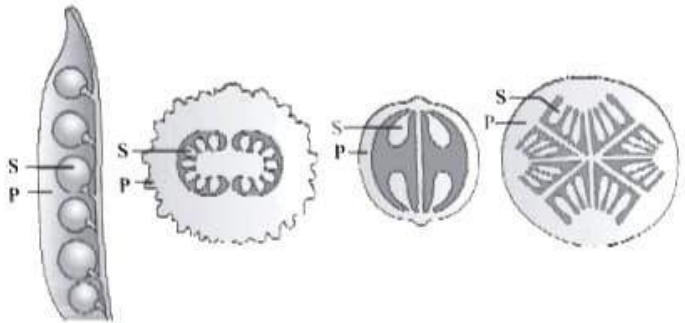


Fig.: A few kinds of fruit showing seeds (S) and protective pericarp (P)