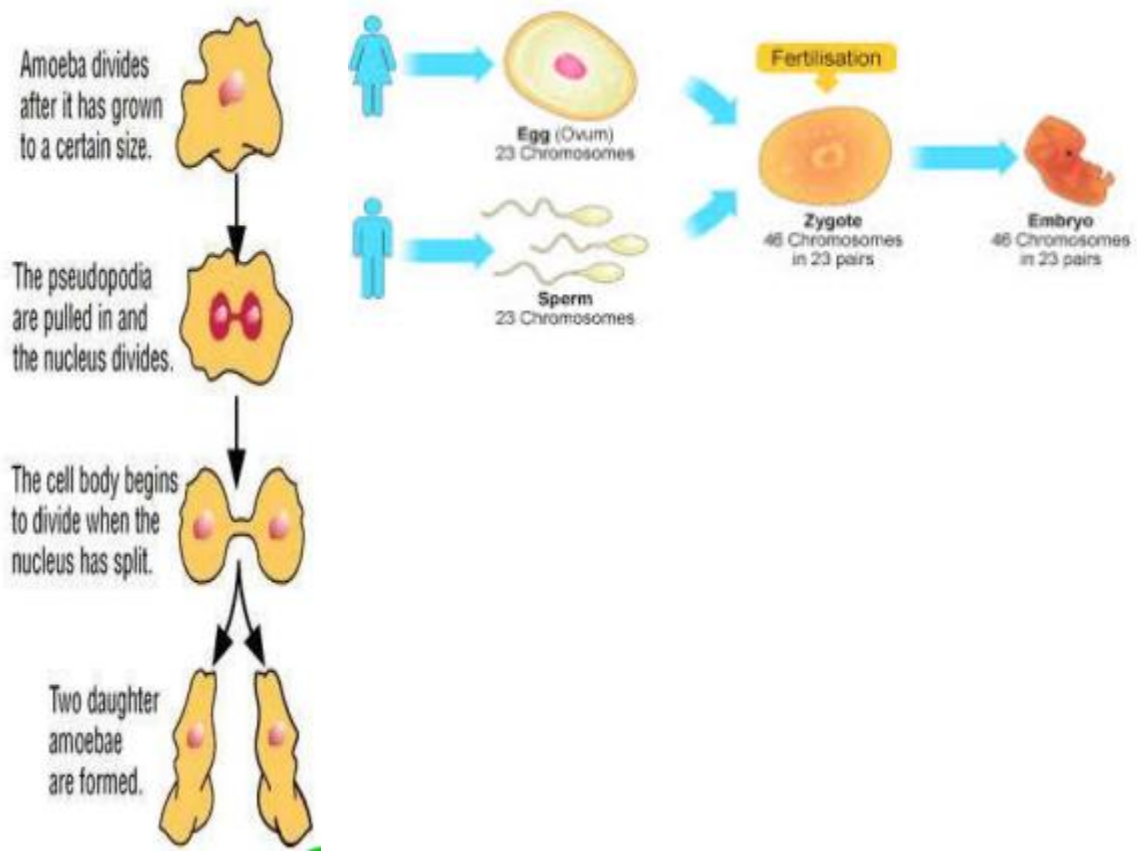
CHAPTER 1

REPRODUCTION IN ORGANISMS

Reproduction is an important biological process by which an organism gives rise to another organism similar to itself.

- Reproduction enables the continuity of the species generation after generation. It results in formation of genetic variation. This genetic variation is inherited during reproduction.
- Reproduction involving a single parent is called **asexual**.
- Reproduction involving two parents of opposite sexes with the fusion of male and female gametes is called **sexual reproduction**.



ASEXUAL REPRODUCTION

- In asexual reproduction, only a single parent is involved in producing offspring. As a result, the off-spring produced are identical to each another as well as to the parent.
- Asexual reproduction is common among single celled organisms, and in plants and animals with relatively simple organizations. It is also seen in multi cellular organisms.

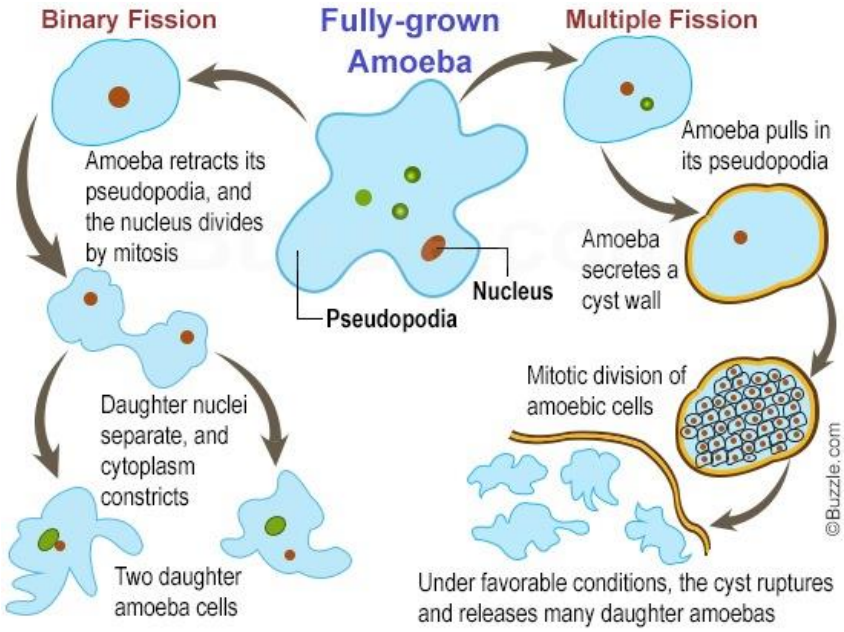
ASEXUAL REPRODUCTION IN ANIMALS

The most common modes of asexual reproduction seen in animals are as follows

1. Fission

- This method is observed in the members of Protista and Monera. In fission, the division of the nucleus occurs first which is then followed by the division of the cytoplasm. Subsequently, the mother cell splits into two equal sized daughter cells.
- When the cytoplasmic division occurs in any direction **(e.g. amoeba)** the fission is called **simple binary fission.**

- When cytoplasm divides along the transverse axis of the individual the fission is termed **transverse binary fission. E.g. *Paramecium* and *Planaria*.**
- When the cytoplasm divides the longitudinal axis of the individual it is designated as **longitudinal binary fission**. E.g. ***Euglena* and *Vorticells*.**
- Binary fission involves mitosis only and consequently the resultant offspring are genetically identical to the parent and to each other.
- In some cases the nucleus divides several times by amitotic divisions. This leads to the formation of multiple new copies of nuclei. Cytoplasmic division does not occur during this period. The cytoplasm collects around each nucleus. Thus from a single cell many unicellular and uni-nucleated offspring are formed. This method of reproduction is called **multiple fission**. E.g. **Amoeba and *Paramecium***.



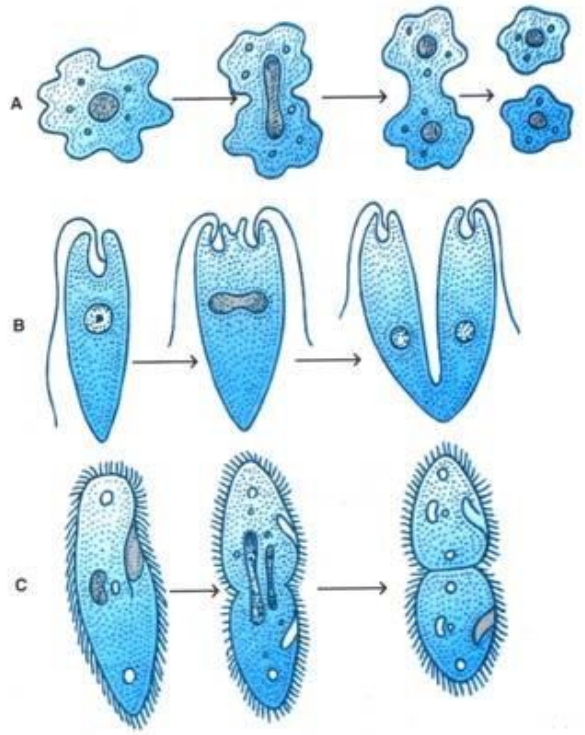


Fig. 1.3. Types of Binary fission in Protozoans. **A.** Irregular in *Amoeba;* **B.** Longitudinal in *Euglena;* **C.** Transverse in *Paramecium.*

Differences between binary and multiple fission-

	Characters	Binary fission	Multiple fission
1.	Number of daughters produced	Parent divides in two daughters.	Parent divides in many daughters.
2.	Time of formation	During favourable conditions.	During unfavour able conditions.
3.	Fate of parent	Nothing is left with parent.	Residual cytoplasm is left.

2. Sporulation

- Sporulation occurs during unfavorable conditions. Organisms **like Amoeba** withdraw their pseudopodia and become round in shape. They create a protective and hard three layered cyst around themselves. This process is called **encystations**.
- Under favorable conditions, the nucleus of encysted Amoeba undergoes multiple divisions to form large number of Amoeba. These structures are called **pseudo-podiospores**. This process is called **sporulation**. The cyst then ruptures to release all new Amoebae. **In *Plasmodium*** this process occurs at a specific stage in its life cycle.

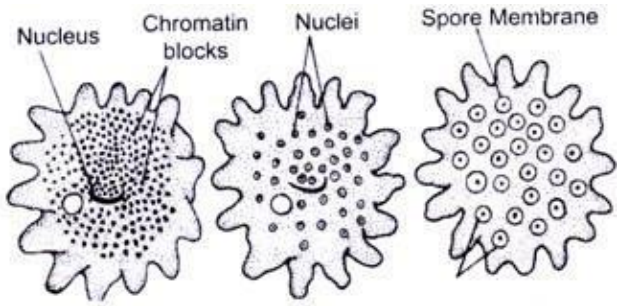


Fig. 9.9 Sporulation in Amoeba

3. Budding

- In this method cells of some parts of the body of the animal undergo repeated mitotic cell divisions. This leads to the formation of overgrown regions of cell masses. Such regions of cell masses that result due to mitosis are called **bud**. A young animal is developed from such a bud. It detaches itself from the parent body and lives as independent animal.
- Such a bud produced on the outside of the body, is called **exogenous budding**. E.g. **Hydra**
- Enveloped cell mass developed towards the inside of the body are called as **internal buds or gemmules.** Such gemmules can be seen in fresh water sponge (e.g. ***Spongilla***) and marine sponge (e.g**. *Sycon***). Each gemmule gives rise to a new animal. This is called **endogenous budding**.

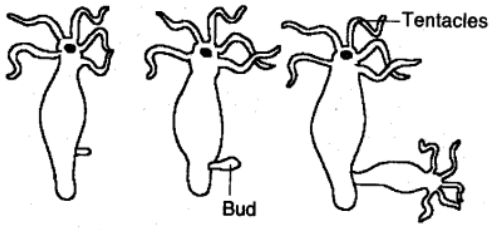
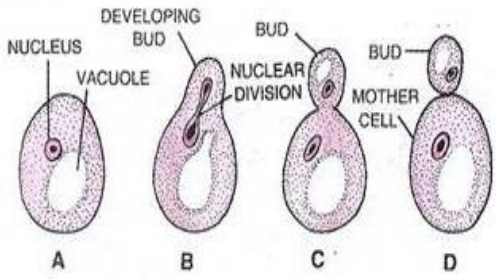


Fig. Budding in *Hydra*.



Budding in yeast.

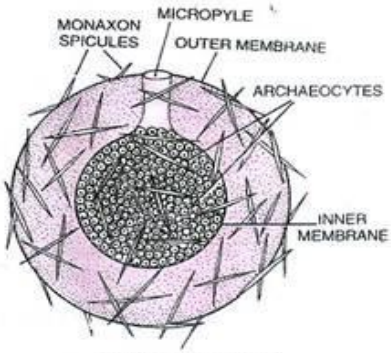
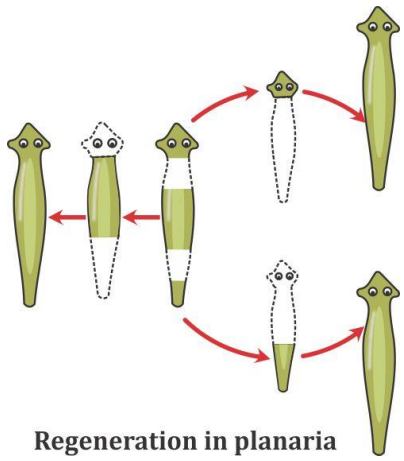


Fig. 1.13. Gemmule

4. Fragmentation

- In this method of reproduction, the body becomes fragmented into several different parts. Each part develops the remaining body parts and becomes a complete animal. This capacity is known as **regeneration**. E.g. ***Planaria, Hydra*, Starfish, etc.**



Regeneration in planaria

ASEXUAL REPRODUCTION IN PLANTS

The commonly observed modes of asexual reproduction in plants are:

1. Fission

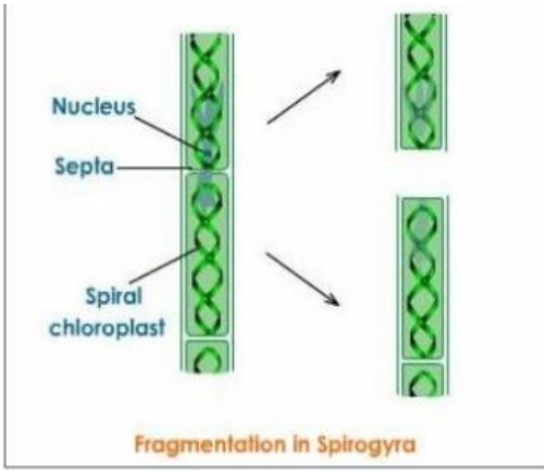
- It is the simplest of all asexual methods. It is commonly found in algae, fungi and monera (bacteria). In this process, the unicellular mother cells divides mitotically to form two daughter cells that are identical to each other as well as the mother cell. Each daughter cell eventually grows into an independent organism.

2. Buds

- Some algae produce adventitious branches **(e.g. *Dictyota, Fucus*)** or buds **(e.g. *Protosiphon***). Fungus like **yeast** produces buds. These structures are a result of unequal division and are attached to the parental cell. They eventually get separated and mature into a new organism.

3. Fragmentation

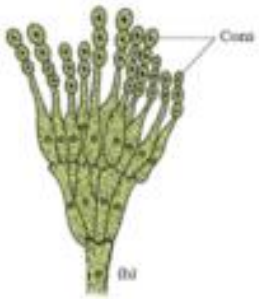
- The vegetative thallus or hyphae break up into small segments due to mechanical pressure. Each segment is capable of growing into a new mycelium. This method is observed in some algae (e.g. *Ulothrix, Dedogonium, Spirogyra* and *Zygnema*) and fungi (e.g. *Mucor, Rhizophus, and Saprolegnia*).



4. Spore formation

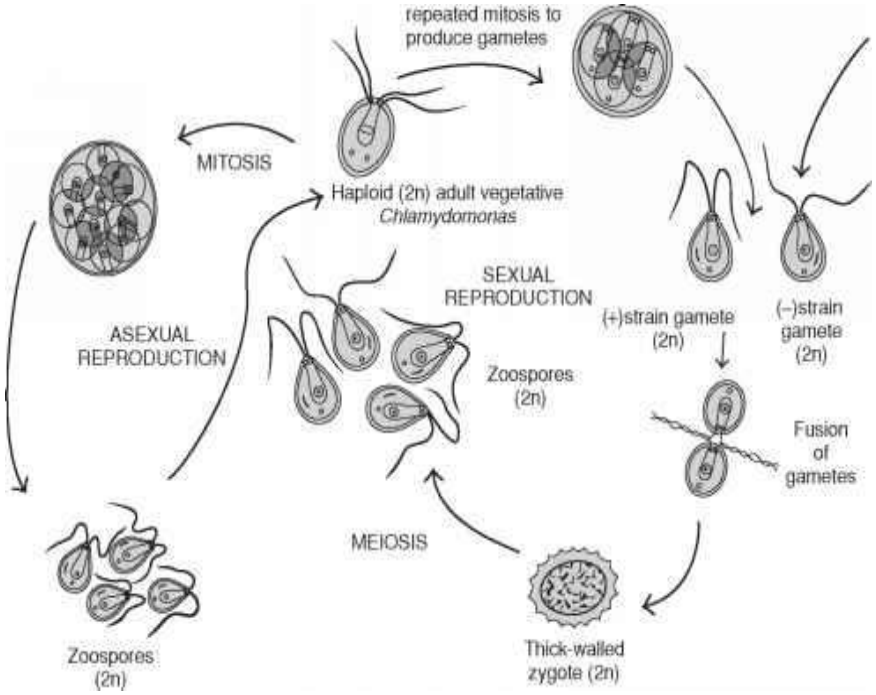
- Asexual reproduction takes place by a variety of motile and non-motile spores / conidia.
- Ciliated motile asexual spore, called **zoospores** are produced by algae and fungi. These zoospores swim in water for some time with the help of their flagella. They later directly develops into new independent individuals under favorable conditions. **e.g. *Ulothrix, Chlamydomonas, Oedogonium*.**
- Terrestrial fungi have non-flagellated and non-motile spores/ conidia. These spores are therefore light and dry. They are also provided with a tough coat and are well adapted for dispersal by wind. **E.g. *Penicillium, Aspergillus***.
- The structure bearing true spores is the sporangium. The sporangium is always present on a sporophyte. Thus, the sporophyte multiplies rapidly in an asexual manner to generate large numbers by spores. Some ferns (***Nephrolepis***) bear spores and reproduce asexually by them. These plants are **homosporous** (bear only one kind of spores).
- While in ***Selaginella*** **(pteridophyte**) and gymnosperms are hetrosporous (bear two types of spores).

Zoospores of *chlamydomonas*



Conidia of *Penicillium*

Gemmules in sponge



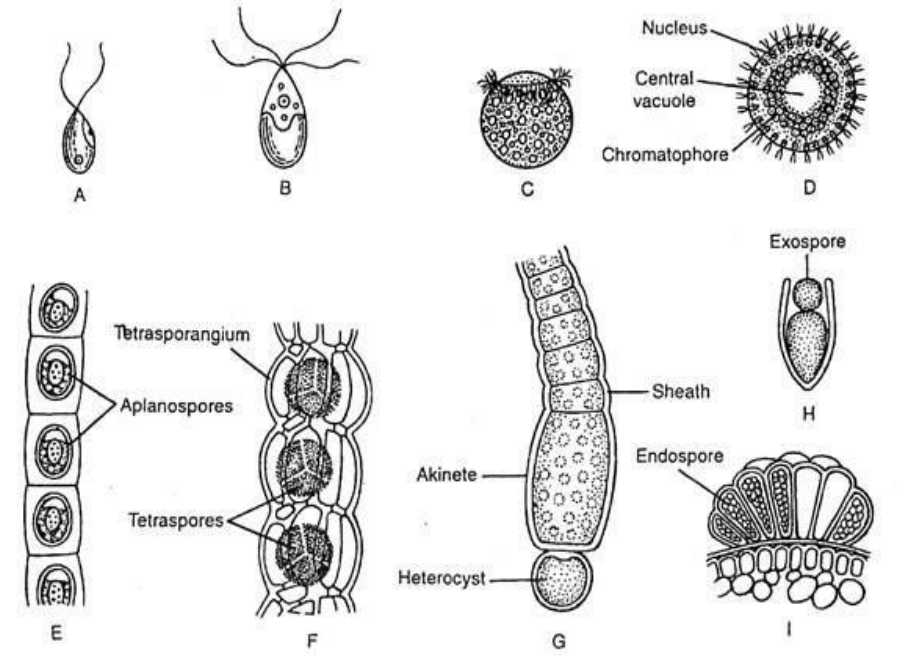


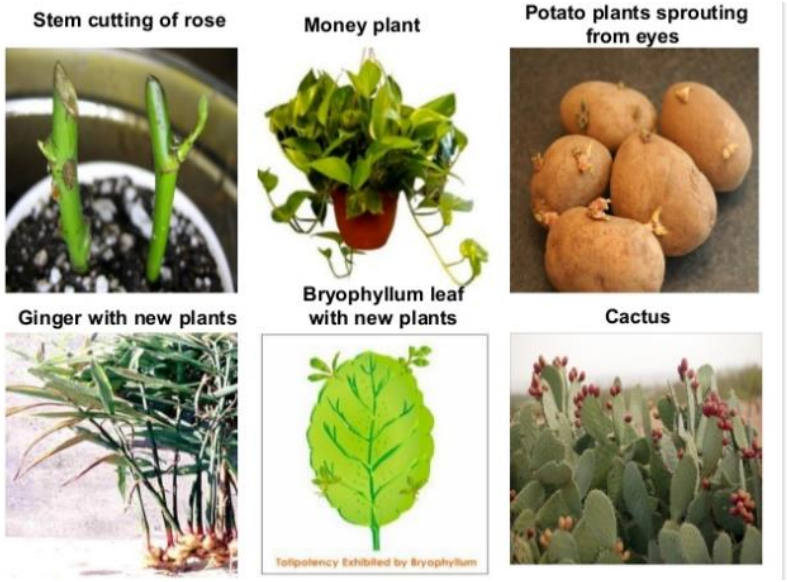
Fig. 3.17 : Asexual spores in algae : A. Biflagellate microzoospore, and B. Quadriflagellate microzoospore of *Ulothrix* sp., C. Multiflagellate zoospore of *Oedogonium* sp., D. Synzoospore of *Vaucheria* sp., E. Aplanospores of *Ulothrix* sp., F. Tetraspores of *Polysiphonia* sp., G. Akinete of *Gloeotrichia* sp., H. Exospore of *Chamaesiphon incrustans*, and I. Endospores of *Dermocarpa prasina*

Vegetative Propagation

In flowering plants the method of vegetative propagation or reproduction are grouped into **natural and artificial**.

(i) NATURAL METHODS

- In natural methods of propagation there is development of a new plant from some organ of the mother plant under suitable environmental conditions. Such modified organs may develop from stem, leaf, root or even flower.
- **Vegetative reproduction**
- Through roots: **sweet potato, *Asparagus* and *Dahlia***.
- Through leaves: In this method buds develop in the margins of leaves. These buds produce new plants as can be seen in ***Bryophyllum***
- Through floral buds: In plants like ***Agave* and *Oxalis,*** floral buds produce new plants and in ***Dioscorea***, axillary buds do so.
- Through stem: **Runners** observed in **lawn grass**, **offsets** found in ***Pistia*, Stolons in *Nephrolepis*** and **Suckers** in **mint plants**.



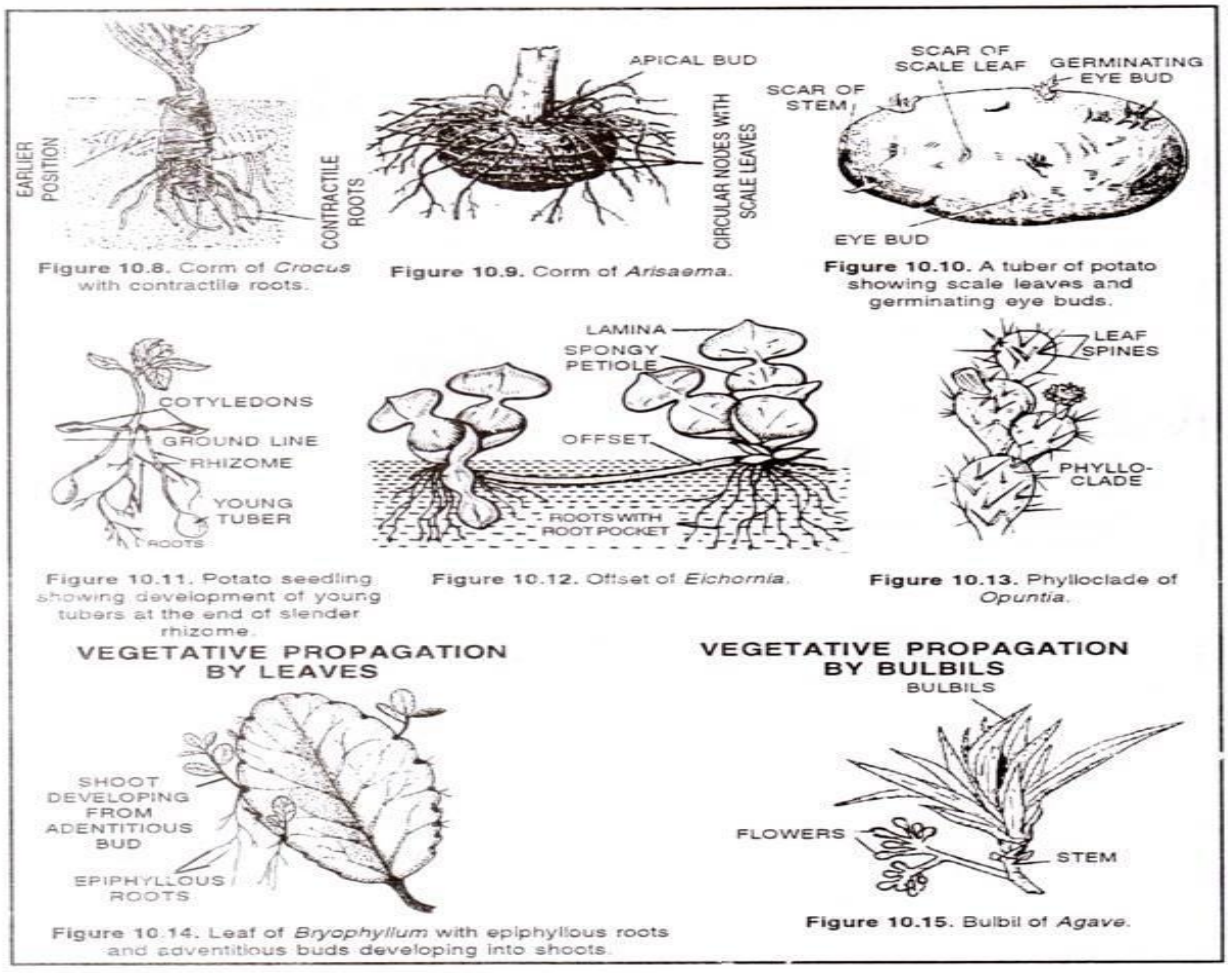


Figure 10.8. Corm of *Crocus* with contractile roots.

Figure 10.9. Corm of *Arisaema*.

Figure 10.10. A tuber of potato showing scale leaves and germinating eye buds.

Figure 10.11. Potato seedling showing development of young tubers at the end of slender rhizome.

Figure 10.12. Offset of *Eichornia*.

Figure 10.13. Phylloclade of *Opuntia*.

Figure 10.14. Leaf of *Bryophyllum* with epiphyllous roots and adventitious buds developing into shoots.

Figure 10.15. Bulbil of *Agave*.

(ii) ARTIFICAL METHODS

- Methods are developed for artificial vegetative propagation in which some part of the plant organ is utilized for obtaining a new complete plant. Amongst them the most common methods are – cutting. Layering and grafting.

a) Cutting

- Cut pieces of root when planted in moist soil leads to the artificial inducement and development of adventitious roots. New plants are developed in this way in **lemon and tamarind**.

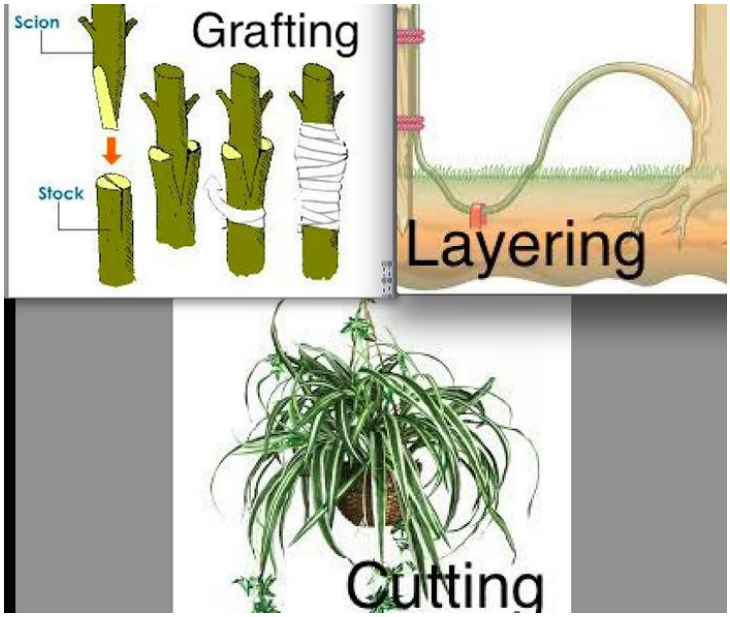
- In **Rose, sugarcane, croton, china-rose and chrysanthemum** plants are developed by cuttings that involve stem pieces containing nodes. They are planted in moist soil to develop new plants. Adventitious roots develop from the underground parts of stem, whereas buds develop and sprout on the aerial parts of stems. The plants, so developed is called a 'cutting'. Later, these cuttings are transplanted in proper places.

b) Layering

- This method is employed in the cultivation of **Rose, Lemon, Grape, Hibiscus and jasmine**. The lower branches of the plants are bent and covered with soil in such a way that the tip of the branch remains outside the soil and the middle portion is buried inside the soil. Adventitious roots will develop from this buried region of plant stem. At that time this branch is cut and separated from the parent plant. Thus, a new plant is obtained.

c) Grafting

- Grafting is practiced in plants which have difficulty in establishing roots or generally have a weak root system. In this method two plants of the same or different kinds are joined together. This is achieved by bringing the tissues of the two plants in direct contact with each other. The meristematic tissue of both plants divide and multiply and eventually the cells of each plant fuse together.
- The rooted plant is called **stock** plant. The plant which is being grafted on it is called **scion**. A plant possessing **higher and desirable characters** is selected as 'scion'. The stock is usually a **strong, sturdy and hardy** variety. **Mango, Apple, Pear, Citrus, Guava, Litchi** and many other fruit – yielding plants are thus obtained and maintained.
- Grafting may be of different types, namely bud grafting, side grafting, and tongue grafting, wedge grafting and crown grafting depending on the methods of uniting the two parts.



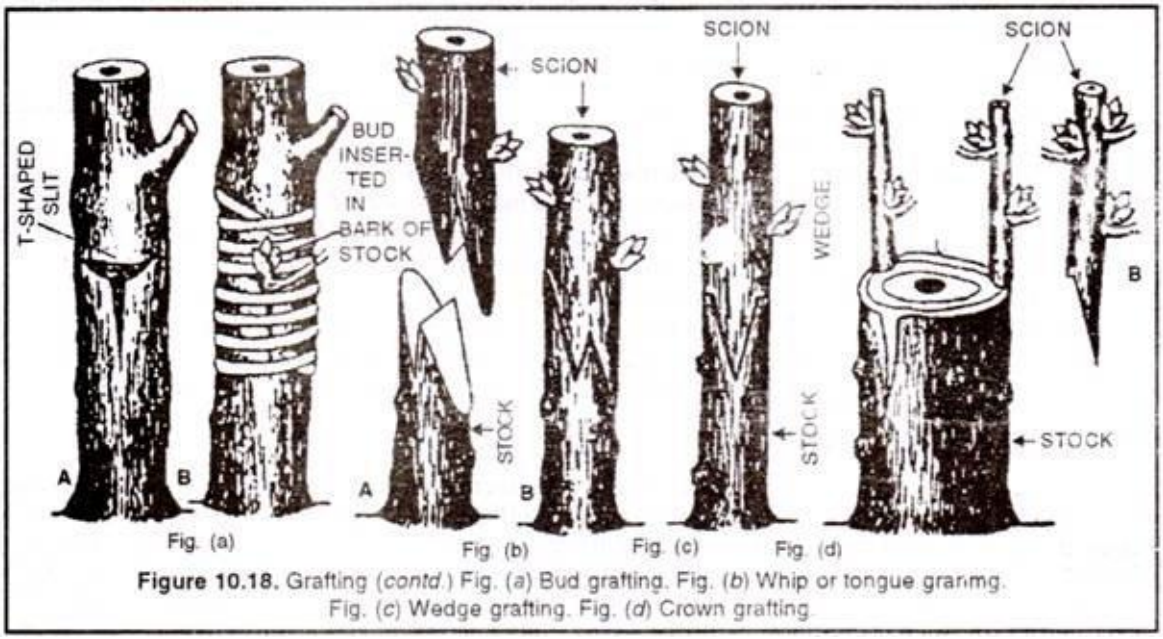


Figure 10.18. Grafting (*contd.*) Fig. (*a*) Bud grafting. Fig. (*b*) Whip or tongue grafting. Fig. (*c*) Wedge grafting. Fig. (*d*) Crown grafting.

SIGNIFICANCE OF VEGETATIVE REPRODUCTION

1. Vegetative reproduction is an ideal method of reproduction in plants where we wish to retain parental traits.

2. It is ideal for plants with less efficient sexual reproduction, small seeds, long seed dormancy, poor seed viability, etc. can also be multiplied easily through this method.

3. Vegetative reproduction is useful in obtaining disease-free plants.

4. Grafting can be used to bring together the desired characters from two plants.

SEXUAL REPRODUCTION

- Sexual reproduction involves formation of the male and female gametes, either by the same individual or by different individuals of the opposite sex.
- The gametes formed then fuse to form the zygote which develops to form the new organism. It is a complex and slow process as compared to asexual reproduction.
- As it involves the fusion of male and female gametes, offspring are not identical to the parents or amongst themselves.
- Even with different external morphology, anatomy and physiology, the sexual mode of reproduction is similar in pattern in plants, animals and fungi. All organisms undergo general growth before reproductive growth. Only when they are reproductively mature they can reproduce sexually. This period of general growth is called the **juvenile phase** and in plants it is known as **vegetative phase**.
- The events and processes of sexual reproduction are fundamentally similar in all organisms. However, the structures associated with sexual reproduction are quite different.
- In all cases, the sexual reproduction is characterized by the fusion of the male and female gametes of the species.
- For convenience these sequential events may be studied as three distinct stages namely, **the pre fertilization, fertilization and the post fertilization.**

PRE-FERTILIZATION EVENTS

1. Gametogenesis

- Gametogenesis is the process of formation of gametes. Gametes are of two types; male and female gametes derived from male and female parent respectively. Gametes are haploid (n) cells.
- Gametes that are similar in appearance are called **isogametes or homogametes**. They are morphologically and physiologically similar (**e.g. *Cladophora, Ulothrix***).

- A majority of sexually reproducing organisms show two morphologically and physiologically distinct types of gametes. Such gametes are called as **heterogametes or anisogametes**. The **male gametes** are **smaller** and more active whereas the **female gametes** are **larger and sluggish**. The male gametes is called **anthrozoid or sperm** and the female gamete is called **egg or ovum**.
- Gametes are always haploids. The parent may be either haploid or diploid. A haploid parent produces haploid gametes by mitotic division.
- Several organism belonging to Monera, Fungi, Algae and Bryophyta, Gymnosperms, Angiosperms and most of the animals are diploid. Here meiosis takes place to produce haploid gametes.
- In diploid organisms when the meiocytes (gamete mother cell, diploid- 2n) undergo meiosis, only one set of chromosomes (n) gets incorporated in each gamete.

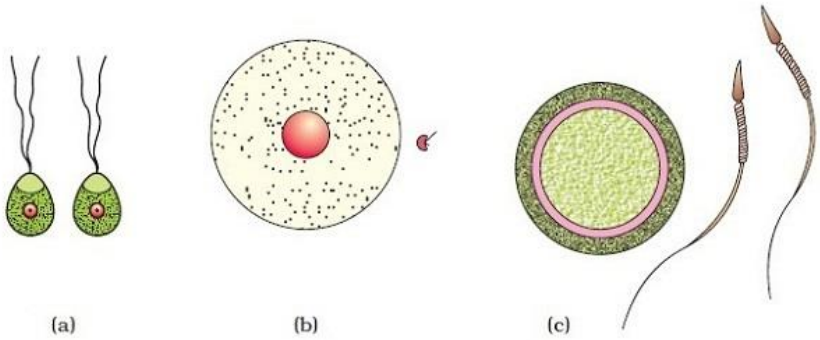
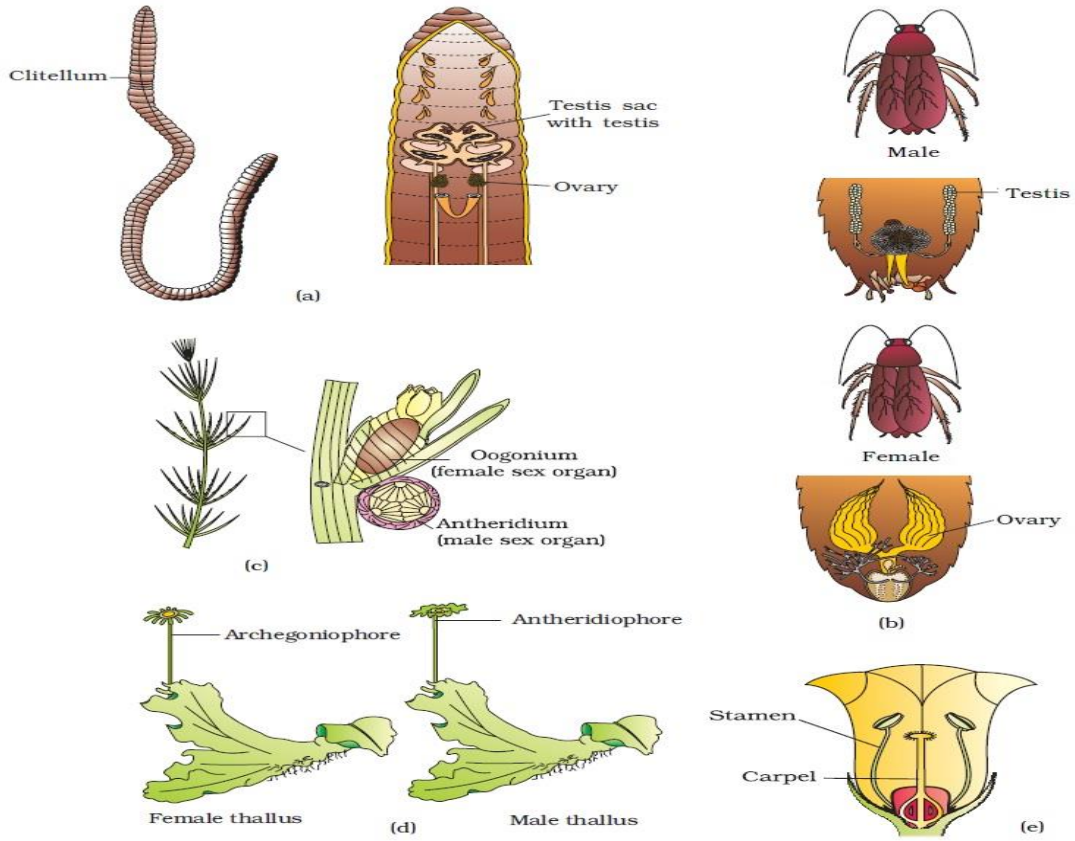


Figure 5. Types of gametes: (a) Isogametes of *Cladophora* (an alga); Heterogametes (b) *Fucus* (an alga); (c) Human beings

Diversity of sexuality in organisms



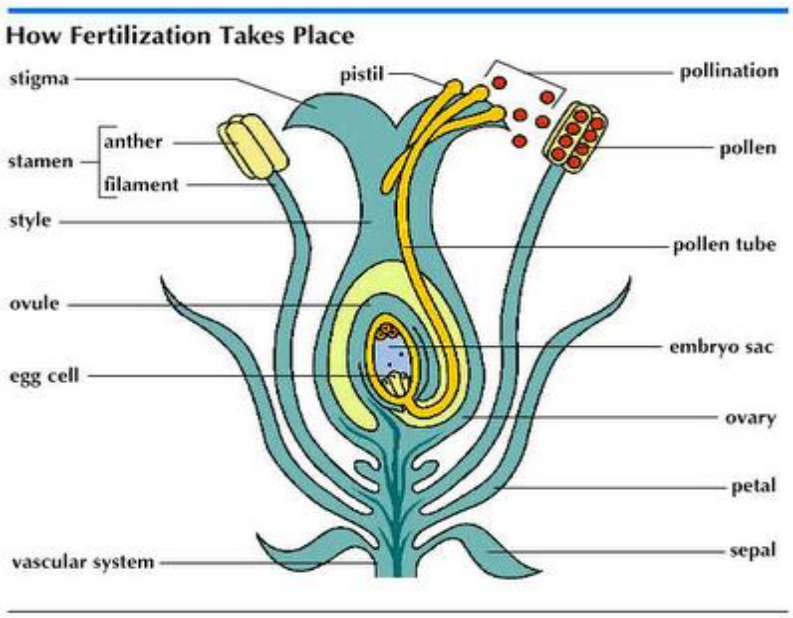
2. Gamete transfer

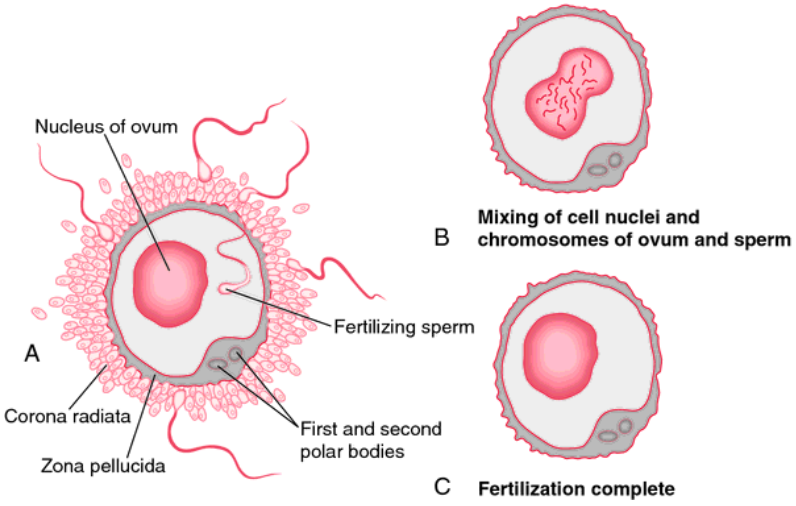
After their formation, the male and female gametes have to come in contact for fertilization. Male gamete is generally motile and the female gamete is usually stationary. Gamete transfer requires a suitable medium. In Algae, Bryophytes and Pteridophytes, water is the medium for gamete transfer.

- A large number of the male gametes fail to reach the female gametes. Therefore, male gametes are synthesized in very large numbers as compared to female gametes.
- In angiosperms, pollen grains carry the male gametes and ovule contains the egg cells. Pollen grains produced in anthers and are transferred to stigma. This phenomenon is known as **pollination**. Pollination requires the involvement of external agents such as insects, animals, wind and water.
- Pollen grains germinate on the stigma and the pollen tubes that carry the male gametes reach the ovule and discharge two gametes near the egg cell.
- In bisexual animals the organism must evolve a special mechanism for gamete transfer since male and female gametes are formed in different individuals. It is essential for fertilization.

FERTILIZATION

- The fusion of male and female gametes is called **syngamy.** As a result diploid zygote is formed. This process is known as **fertilization**.
- In majority of algae, fishes and amphibians syngamy occurs outside the body of organisms. This type of gametic fusion is called **external fertilization**. This is seen in the bony fishes and frogs where a large number of offspring are produced. The offspring are extremely vulnerable to predators. This poses a threat to their survival.
- In plants (i.e. fungi, bryophytes and pteridophytes) as well as reptiles, birds and mammals, syngamy occurs inside the body of the organism. Hence the process is called **internal fertilization**. In this process, the motile male gametes reach and fuse with the egg. This takes place inside the female body.
- In seed plants, the non-motile male gametes are carried to female gamete by pollen tubes.

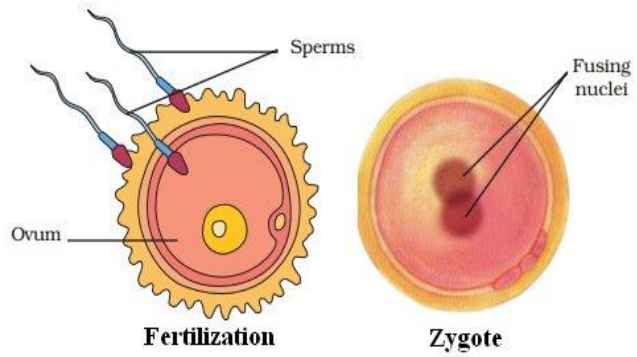




POST-FERILIZATION EVENTS

1. Zygote

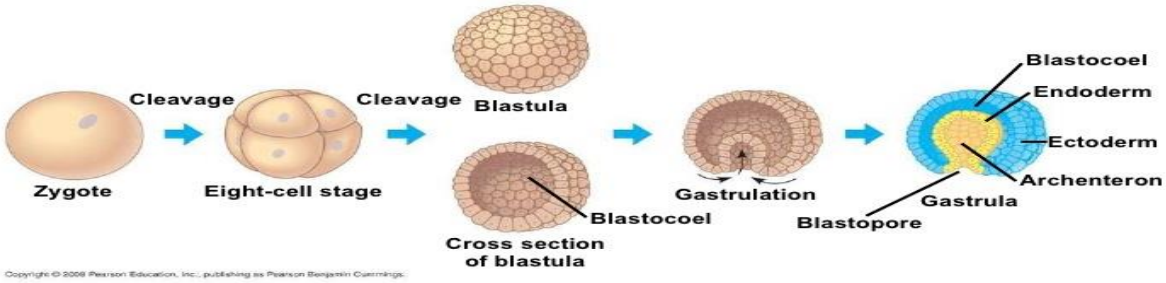
- Formation of zygote (2n) is common in sexual reproduction. In external fertilization, the zygote is formed in the external medium (water), whereas in internal fertilization, zygote is formed inside the body of organisms.
- Further development of zygote depends on the life cycle of the organism and the environment to which it is exposed. In organisms, such as algae and fungi, zygote develops a thick wall resistant to desiccation and damage and commonly it undergoes a period of rest prior to germination.
- Some unicellular animals (**e.g. *Paramoecium***) exhibit sexual reproduction by forming male and female gamete nuclei, which they exchange through temporary cytoplasmic bridge. Later the cytoplasmic bridge appears and the gamete nucleus of one individual fuses with that of the other to form zygote nucleus. This mode of sexual reproduction is known as **conjugation**.
- Zygote is the vital link that ensures continuity of species between organism of one generation and the next.

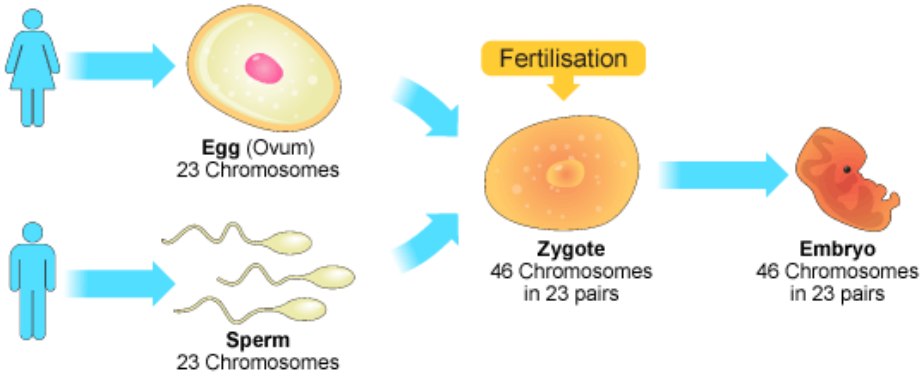


2. Embryogenesis

- Embryogenesis is the process of development of embryo from the zygote. During embryogenesis zygote undergoes cell division (mitosis) and cell differentiation.
- Cell divisions increase the number of cells in the developing embryo while cell differentiation helps group of cells to undergo certain modifications to form specialized tissues and organs to form organism.
- In animals, when the development of zygote takes place inside the body of the female parent, it is called **viviparous**.
- In **oviparous animals like Reptile and Birds** the fertilized eggs covered by hard **calcerous shell** are laid in a safe place in the environment. After a period of incubation, young ones hatch out.
- On the other hand, in **viviparous animals** like mammals including **human beings**, the zygote develops into a young ones are delivered out of the body of the female parent. The chances of survival of young ones, are greater in viviparous organisms because of proper embryonic care and protection.

Fig. 32-2-3



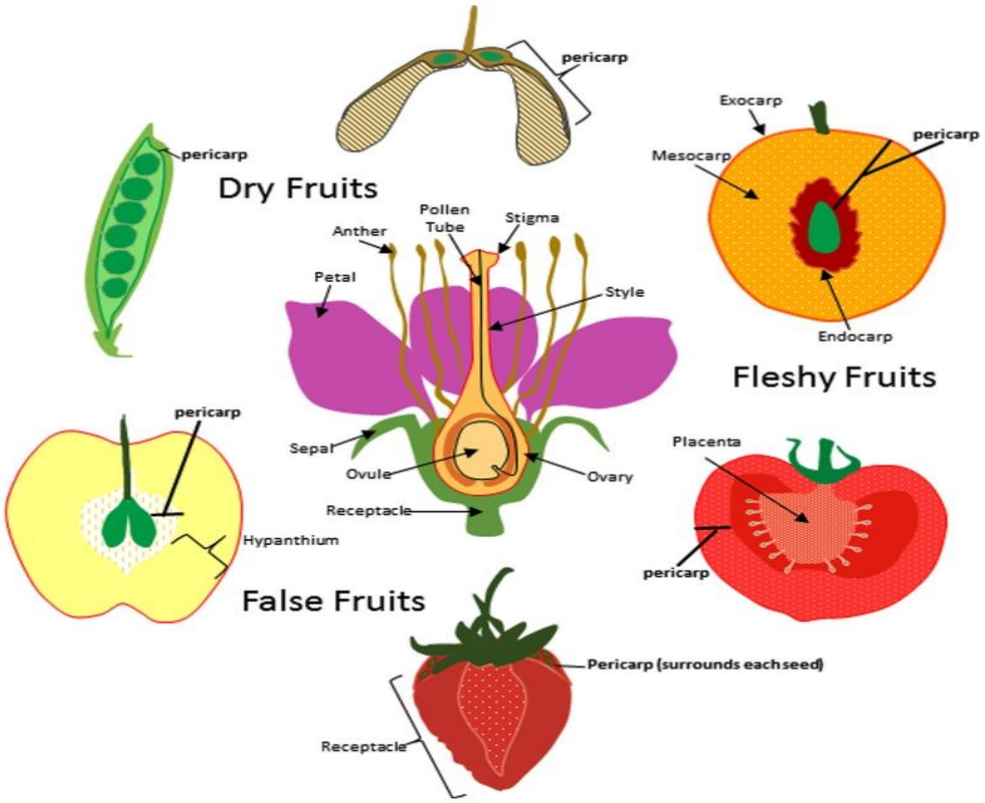


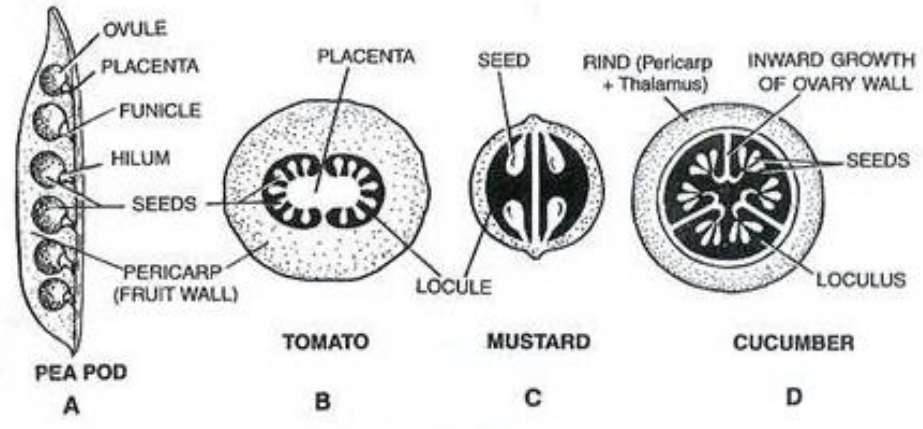
Name of organism	Chromosome number in meiocyte (2n)	Chromosome number in gamete (n)
Human beings	*46*	*23*
House fly	*12*	—
Rat	—	*21*
Dog	*78*	—
Cat	—	*19*
Fruit fly	*8*	—
Ophioglossum (a fern)	—	*630*
Apple	*34*	—
Rice	—	*12*
Maize	*20*	—
Potato	—	*24*
Butterfly	*380*	—
Onion	—	*16*

- In Angiosperms, the zygote is formed, inside the ovule. After fertilization, the sepals, petals and stamens of the flower fall off. The pistil, however, remains attached to the plant.
- In plants:

    a. **Zygote develops into embryo.**
    b. **Ovule develops into seed**
    c. **Integument of the ovule develops into seed coat.**
    d. **Ovary develops into fruit.**
    e. **Ovary wall develops into pericarp, is protective in function.**

    After dispersal, seeds germinate under favorable condition to produce new plants.





A few kinds of fruits showing seeds and protective pericarp.
A, L.S. Pod (Fruit) of Pea. B,C & D, T.S. ovaries.