

# CHAPTER 1

## REPRODUCTION IN ORGANISMS

- **Life span** - The period from birth to the natural death of an organism represents its life span.

life spans of organisms are not necessarily correlated with their sizes.

Life span of various organisms –

Name of organism	Life-span
Elephant	
Dog	
Butterfly	1-2 weeks
Crow	15 years
Parrot	140 years
Cow	
Horse	
Crocodile	60 years
Fruit fly	
Tortoise	100-150 years
Rose	
Banana tree	
Rice plant	
Banyan tree	

Whatever be the life span, death of every individual organism is a certainty, i.e., no individual is immortal, except single-celled organisms.

- There is no natural death in single-celled organisms as they divide and form 2 new cells.
- **Reproduction** –
  - it is defined as a biological process in which an organism gives rise to young ones (offspring) similar to itself.
  - The offspring grow, mature and in turn produce new offspring. Thus, there is a cycle of birth, growth and death.
  - Reproduction enables the continuity of the species, generation after generation.
  - genetic variation is created and inherited during reproduction.
  - There is a large diversity in the mechanism of reproduction of organisms. The organism's habitat, its internal physiology and several other factors are collectively responsible for how it reproduces.
- **Type of reproduction** –
 

Reproduction is of two types –

  - When offspring is produced by a single parent with or without the involvement of gamete formation, the reproduction is **asexual**.
  - When two parents (opposite sex) participate in the reproductive process and also involve fusion of male and female gametes, it is called **sexual reproduction**.
- **Asexual Reproduction** –
  - In this method, a single individual (parent) is capable of producing offspring.

- The offspring that are produced are not only identical to one another but are also exact copies of their parent. These offspring are also genetically identical to each other. The term **clone** is used to describe such morphologically and genetically similar individuals.
- Asexual reproduction is common among single-celled organisms, and in plants and animals with relatively simple organisations.
- In Protists and Monerans, (All unicellular) 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.
  - **Binary Fission** – In many single-celled organisms cell divides into two halves and each rapidly grows into an adult (e.g., *Amoeba*, *Paramecium*).
  - **Budding** – In yeast, the division is unequal and small **buds** are produced that remain attached initially to the parent cell which, eventually gets separated and mature into new yeast organisms (cells).
  - **Special reproductive structures** – Members of the Kingdom Fungi and simple plants such as algae reproduce through special asexual reproductive structures. The most common of these structures are **zoospores** that usually are microscopic motile structures. Other common asexual reproductive structures are **conidia** (*Penicillium*), **buds** (*Hydra*) and **gemmules** (sponge).
  - **Vegetative propagation** – vegetative reproduction is also asexual process as only one parent is involved. In plants, the term vegetative reproduction is frequently used. e.g., the units of vegetative propagation in plants – runner, rhizome, sucker, tuber, offset, bulb. These structures are called **vegetative propagules**.

Water hyacinth, an aquatic weed, also known as 'terror of Bengal' propagate vegetatively. Earlier 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 drain oxygen from water body and cause death of fishes. (Eutrophication)

Other examples of vegetative reproduction – potato, sugarcane, banana, ginger, dahlia. These plant propagate through buds (called eyes) present on nodes of modified stem.

*Bryophyllum* show vegetative propagation from the notches present at margins of leaves.
- Asexual reproduction is the common method of reproduction in organisms that have a relatively simple organisation, like algae and fungi.
- These organisms shift to sexual method of reproduction just before the onset of adverse conditions.
- In higher plants both Asexual (vegetative) as well as sexual modes of reproduction are exhibited.
- In most of the animals only sexual mode of reproduction is present.

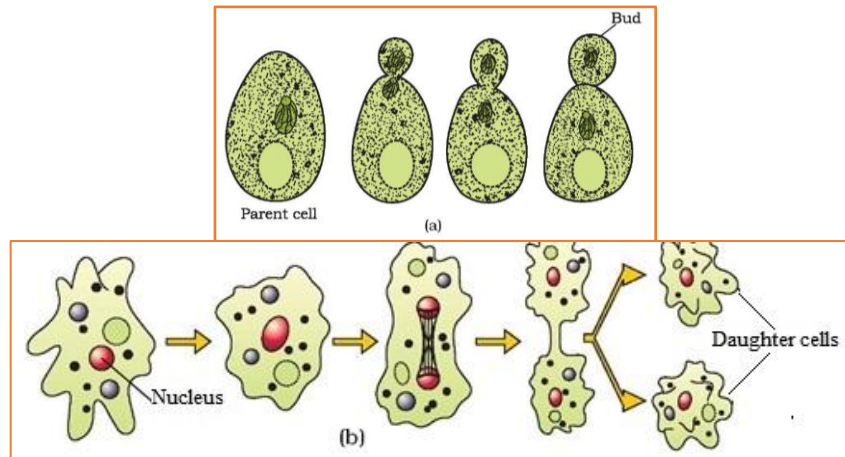


Fig: Cell division in unicellular organism: (a) Budding in yeast; (b) Binary fission in *Amoeba*.

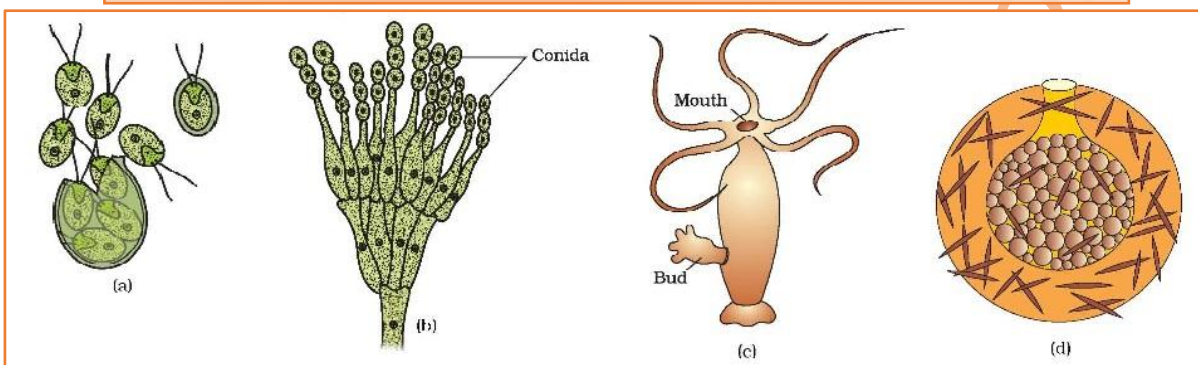


Fig: Asexual reproductive structures: (a) Zoospores of *Chlamydomonas*; (b) Conidia of *Penicillium*; (c) Buds in *Hydra*; (d) Gemmules in sponge

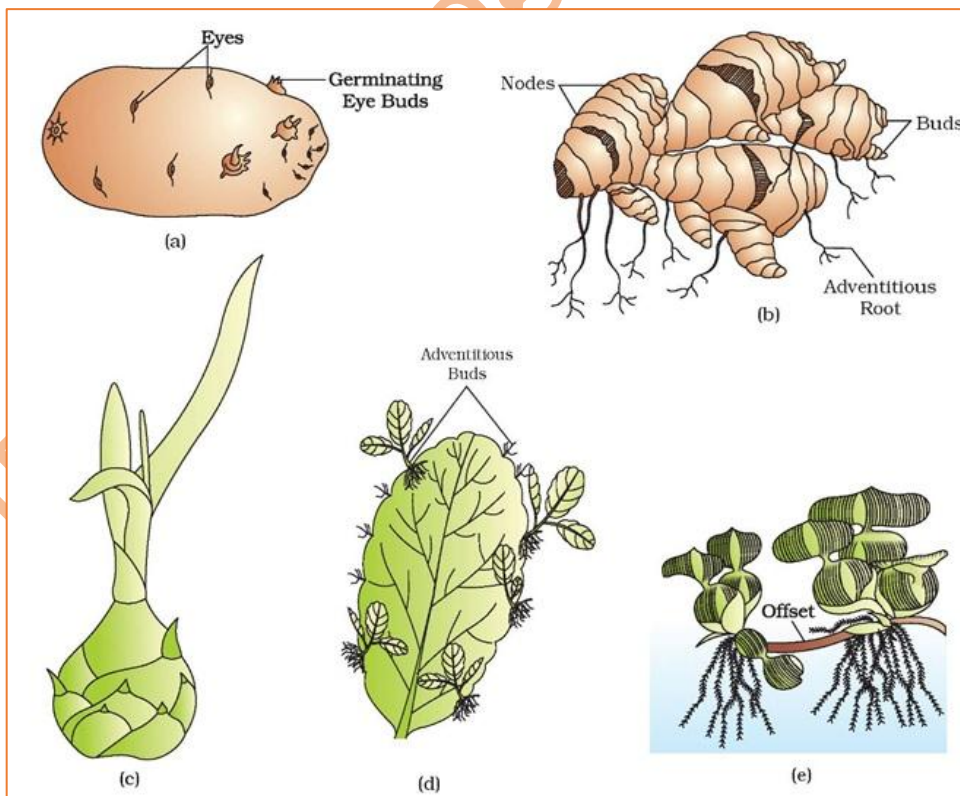


Fig: Vegetative propagules in angiosperms: (a) Eyes of potato; (b) Rhizome of ginger; (c) Bulbil of *Agave*; (d) Leaf buds of *Bryophyllum*; (e) Offset of water hyacinth

- **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. 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.
- Because of the fusion of male and female gametes, sexual reproduction results in offspring that are not identical to the parents or amongst themselves.
- Plants, animals, fungi show great diversity in external morphology, internal structure and physiology, but in sexual reproduction they share a similar pattern.
- **Juvenile / vegetative phase** – All organisms have to reach a certain stage of growth and maturity in their life, before they can reproduce sexually. That period of growth is called the **juvenile phase**. It is known as **vegetative phase** in plants.
- **Reproductive phase** – the beginning of the reproductive phase can be seen easily in the higher plants when they come to flower.
- In some plants, where flowering occurs more than once, inter-flowering period is also known as juvenile period.
- Plants-the annual and biennial types, show clear cut vegetative, reproductive and senescent phases, but in the perennial species it is very difficult to clearly define these phases.
- Bamboo species flower only once in their life time, generally after 50-100 years, produce large number of fruits and die.
- *Strobilanthes kunthiana* (neelakuranji), flowers once in 12 years. It is found in hilly areas in Kerala, Karnataka and Tamil Nadu.
- In animals, the juvenile phase is followed by morphological and physiological changes prior to active reproductive behaviour.
- birds living in nature lay eggs only seasonally. However, birds in captivity (as in poultry farms) can be made to lay eggs throughout the year. In this case, laying eggs is not related to reproduction but is a commercial exploitation for human welfare.
- The females of placental mammals exhibit cyclical changes in the activities of ovaries and accessory ducts as well as hormones during the reproductive phase.
- In non-primate mammals like cows, sheep, rats, deers, dogs, tiger, etc., such cyclical changes during reproduction are called **oestrus cycle** where as in primates (monkeys, apes, and humans) it is called **menstrual cycle**.
- Many mammals, especially those living in natural, wild conditions exhibit such cycles only during favourable seasons in their reproductive phase and are therefore called seasonal breeders. Many other mammals are reproductively active throughout their reproductive phase and hence are called continuous breeders.
- **Senescent phase** – The end of reproductive phase can be considered as one of the parameters of senescence or old age. There are concomitant changes in the body (like slowing of metabolism, etc.) during this last phase of life span. Old age ultimately leads to death.
- In both plants and animals, hormones are responsible for the transitions between the three phases. Interaction between hormones and certain environmental factors regulate the reproductive processes and the associated behavioural expressions of organisms.

- **Events in sexual reproduction**
  - Sexual reproduction is characterised by the fusion (or fertilisation) of the male and female gametes, the formation of zygote and embryogenesis.
  - These sequential events may be grouped into three distinct stages namely, the pre-fertilisation, fertilisation and the post-fertilisation events.
- **Pre-fertilisation Events**
  - These include all the events of sexual reproduction prior to the fusion of gametes.
  - The two main pre-fertilisation events are gametogenesis and gamete transfer.
  - **Gametogenesis –**
    - It refers to the process of formation of the two types of gametes - male and female.
    - Gametes are haploid cells.
    - In some algae the two gametes are so similar in appearance that it is not possible to categorise them into male and female gametes. They are hence, are called **homogametes (isogametes)**.
    - However, in a majority of sexually reproducing organisms the gametes produced are of two morphologically distinct types (**heterogametes**). In such organisms the male gamete is called the **antherozoid or sperm** and the female gamete is called the **egg or ovum**.

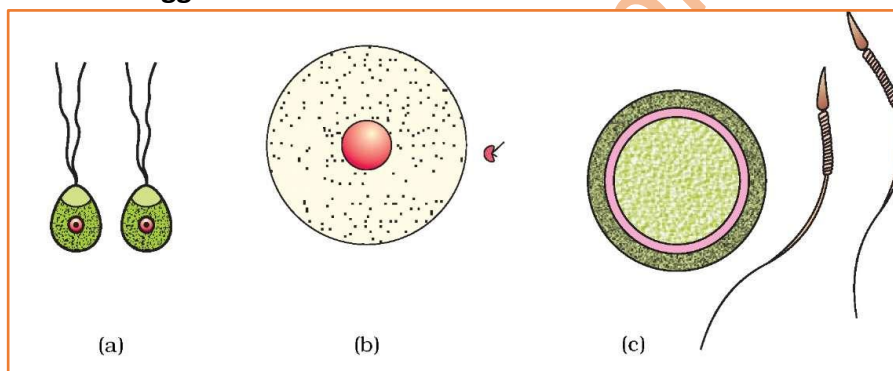


Fig: Types of gametes: (a) Isogametes of *Cladophora* (an alga); Heterogametes (b) *Fucus* (an alga); (c) Human beings

- **Sexuality in organisms:**
  - Plants may have both male and female reproductive structures in the same plant (bisexual) or on different plants (unisexual).
  - In several fungi and plants, terms such as **homothallic and monoecious** are used to denote the bisexual condition and **heterothallic and dioecious** are the terms used to describe unisexual condition.
  - In flowering plants, the unisexual male flower is **staminate**, i.e., bearing stamens, while the female is **pistillate** or bearing pistils.
  - e.g., examples of monoecious plants – cucurbits and coconuts
  - dioecious plants – Papaya and date palm.
  - Earthworms, sponge, tapeworm and leech are examples of bisexual animals (hermaphrodite). Cockroach is an example of a unisexual species.
- **Cell division during gamete formation:**
  - Gametes in all heterogametic species are of two types namely, **male** and **female**. Gametes are **haploid** though the parent plant body from which they arise may be either haploid or diploid.

- A haploid parent produces gametes by mitotic division like in monera, fungi, algae and bryophytes
- In pteridophytes, gymnosperms, angiosperms and most of the animals including human beings, the parental body is **diploid**. In these, specialised cells called **meiocytes** (gamete mother cell) undergo meiosis.
- At the end of meiosis, only one set of chromosomes gets incorporated into each **gamete**.

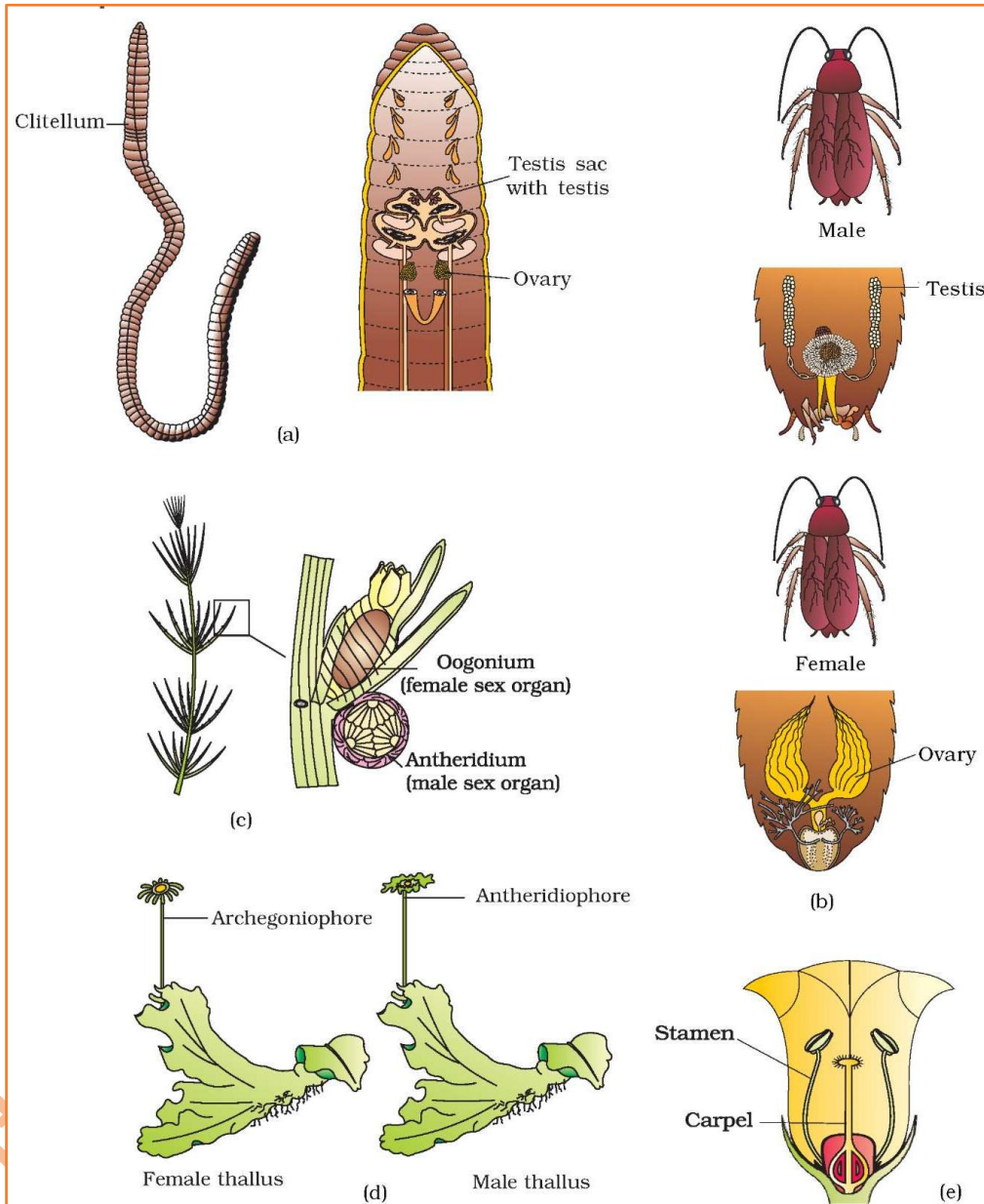


Fig: Diversity of sexuality in organisms (a) Bisexual animal (Earthworm); (b) Unisexual animal (Cockroach); (c) Monoecious plant (*Chara*); (d) Dioecious plant (*Marchantia*); (e) Bisexual flower (sweet potato)

Name of organism	Chromosome number in meiocyte (2n)	Chromosome number in gamete (n)
<i>Human beings</i>	46	23
<i>House fly</i>	12	6
<i>Rat</i>	42	21
<i>Dog</i>	78	39
<i>Cat</i>	38	19
<i>Fruit fly</i>	8	4
<i>Ophioglossum (a fern)</i>	1260	630
<i>Apple</i>	34	17
<i>Rice</i>	24	12
<i>Maize</i>	20	10
<i>Potato</i>	48	24
<i>Butterfly</i>	380	190
<i>Onion</i>	32	16

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

#### ▪ Gamete Transfer:

- After formation, male and female gametes must be physically brought together to facilitate fusion (fertilisation).
- In most of organisms, male gamete is motile and the female gamete is stationary.
- Exceptions – few fungi and algae in which both types of gametes are motile.
- For transfer of male gametes, a medium is needed. In several simple plants like algae, bryophytes and pteridophytes, water is the medium for gamete transfer.
- A large number of the male gametes, however, fail to reach the female gametes. To compensate this loss of male gametes during transport, the number of male gametes produced is very high.
- 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 fertilization.
- 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.
- in cross pollinating plants (including dioecious plants), a specialised event called **pollination** facilitates transfer of pollen grains to the stigma.
- Pollen grains germinate on the stigma and the pollen tubes carrying the male gametes reach the ovule and discharge male gametes near the egg.
- In dioecious animals, since male and female gametes are formed in different individuals, the organism must evolve a special mechanism for gamete transfer. Successful transfer and coming together of gametes is essential for the most critical event in sexual reproduction, the fertilisation.

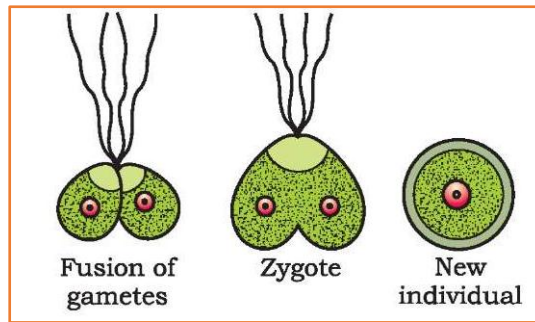


Fig: Homogametic contact in alga

- **Fertilisation**
  - The most vital event of sexual reproduction is perhaps the fusion of gametes. This process is also called **syngamy** results in the formation of a diploid **zygote**.
  - in some organisms like rotifers, honeybees and even some lizards and birds (turkey), the female gamete undergoes development to form new organisms without fertilisation. This phenomenon is called **parthenogenesis**.
  - 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. A major disadvantage 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 the 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 these even though the number of sperms produced is very large, there is a significant reduction in the number of eggs produced. In seed plants, however, the non-motile male gametes are carried to female gamete by pollen tubes.
- **Post-fertilisation Events**
  - Events in sexual reproduction after the formation of zygote are called **post-fertilisation events**.
  - **Zygote :**
    - Formation of the diploid zygote is universal in all sexually reproducing organisms.
    - In organisms with external fertilisation, zygote is formed in the external medium (usually water), whereas in those exhibiting internal fertilisation, zygote is formed inside the body of the organism.
    - Further development of the zygote depends on the type of life cycle the organism has and the environment it is exposed to.



- In organisms belonging to fungi and algae, zygote develops a thick wall that is resistant to desiccation 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.
- Zygote is the vital link that ensures continuity of species between organisms of one generation and the next.
- Every sexually reproducing organism, including human beings begin life as a single cell-the zygote.
- **Embryogenesis :**
  - It 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.
  - Animals are categorised into **oviparous** and **viviparous** based on whether the development of the zygote take place outside the body of the female parent or inside, i.e., whether they lay fertilised/unfertilised eggs or give birth to young ones.
  - In oviparous animals like reptiles and birds, the fertilised eggs covered by hard **calcareous shell** are laid in a safe place in the **environment**; after a period of incubation young ones hatch out.
  - in viviparous animals (majority of mammals including human beings), the zygote develops into a young one inside the body of the female organism. After attaining a certain stage of growth, the young ones are delivered out of the body of the female organism. Because of proper embryonic care and protection, the chances of survival of young ones is greater in viviparous organisms.
  - In flowering plants, the zygote is formed inside the ovule. After fertilisation the sepals, petals and stamens of the flower wither and fall off.
  - The pistil however, remains attached to the plant. The zygote develops into the embryo and the ovules develop into the seed. The **ovary** develops into the **fruit** which develops a thick wall called **pericarp** that is protective in function. After dispersal, seeds germinate under favourable conditions to produce new plants.

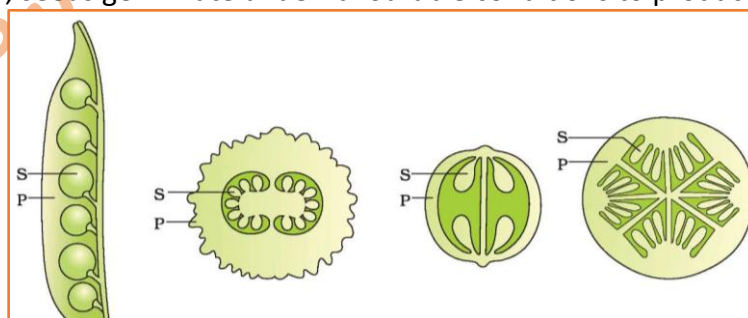


Fig: A few kinds of fruit showing seeds (S) and protective pericarp(P)