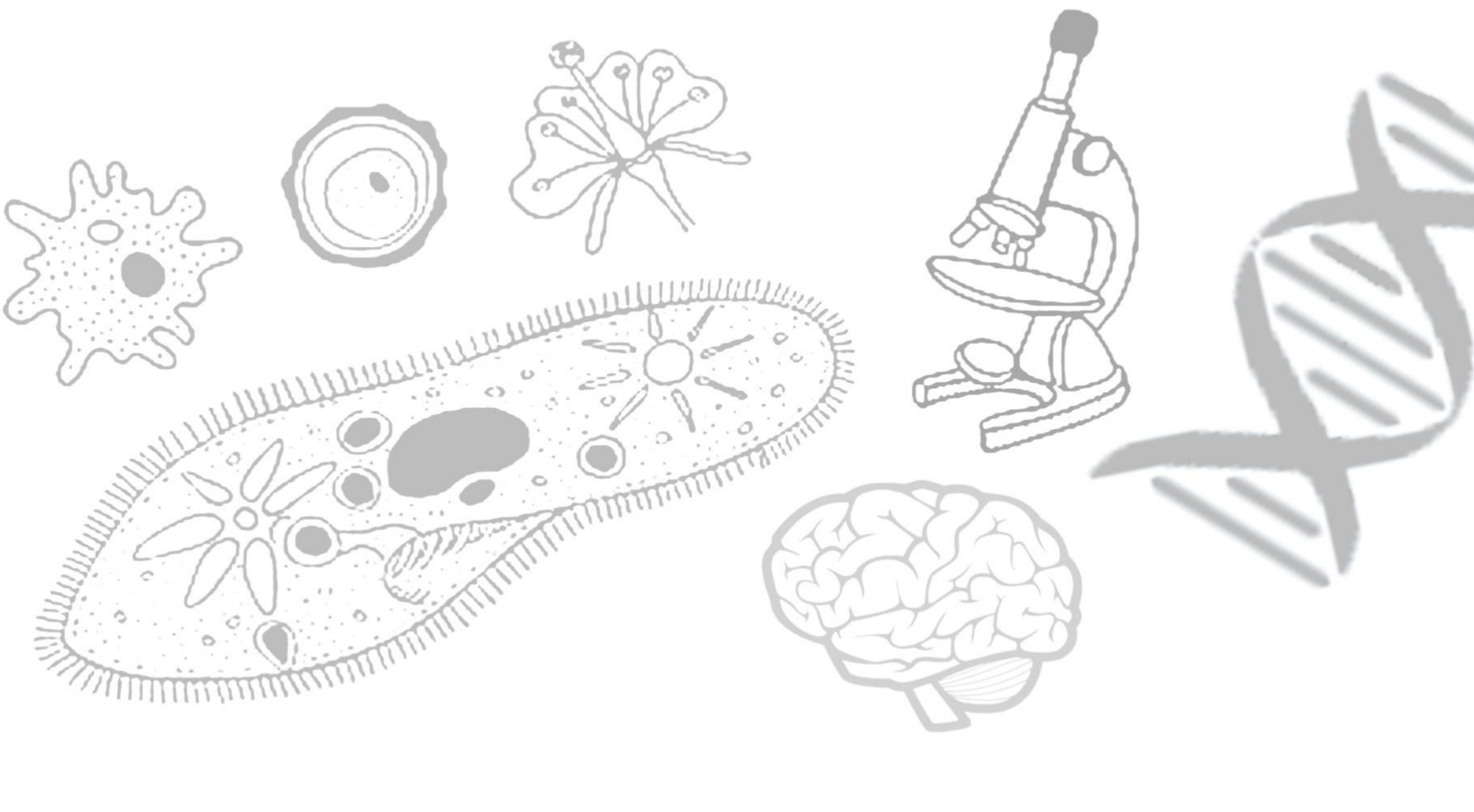
BIOLOGY



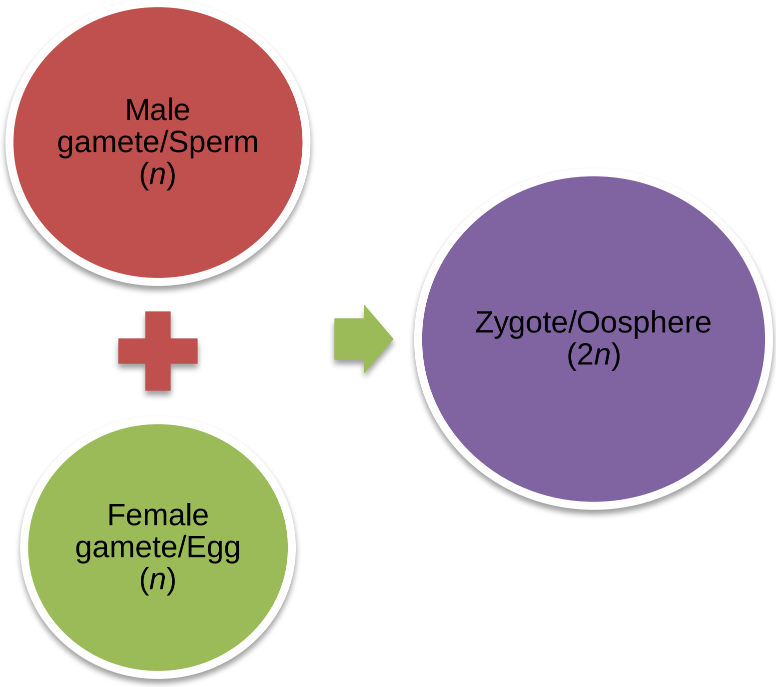
Double Fertilisation, Post Fertilisation: Structures and Events

Contents

Double Fertilisation

Double Fertilisation

- The process of fusion of one male gamete with the egg along with the union of the second male gamete with the two polar nuclei or the secondary nucleus is called double fertilisation.
- Of the two male gametes, one fuses with the egg to carry out generative fertilisation or syngamy. It gives rise to a diploid zygote or oosphere.



- The nucleus of the second male gamete fuses with two haploid polar nuclei or the diploid secondary nucleus of the central cell to form a triploid primary endosperm nucleus (PEN). The central cell is called the primary endosperm cell (PEC). This is called vegetative fertilisation or triple fusion.

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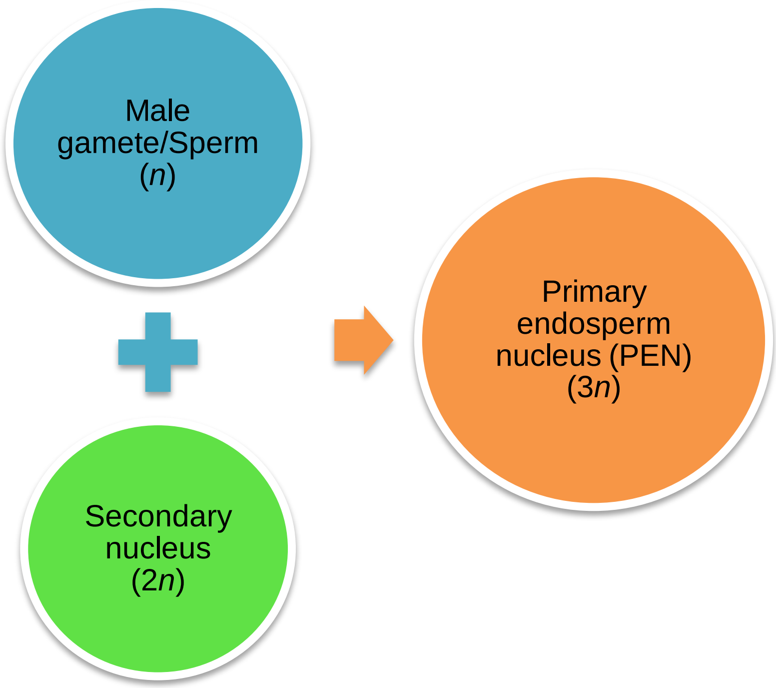

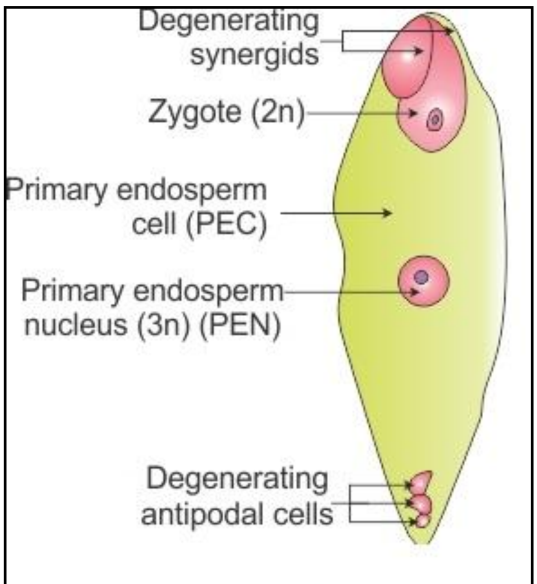

Double Fertilisation

Significance of Double Fertilisation

- Vegetative fertilisation provides a stimulus to one of its cells to resume growth and form a nutritive tissue.
- Double fertilisation ensures that the nutritive tissue is formed only when the formation of embryo has taken place by the fertilisation of the egg.
- It provides the characteristics of the male plant and to the nutritive tissue or the endosperm. It is the only process wherein two male gametes brought by the pollen tube fuse with two different cells of the same female gametophyte in order to produce two different structures.
- Because of its triploid nature, the endosperm shows high physiological activity, grows faster and accumulates nutrients.

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DID YOU KNOW ?

The process of double fertilisation was demonstrated for the first time by Nawaschin (1898) in *Fritillaria* and *Lilium*.

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Post-fertilisation: Structures and Events

Post-fertilisation Changes

- After fertilisation, the zygote, primary endosperm nucleus, ovary and ovule undergo a series of changes.
- Development of endosperm and embryo, maturation of ovules into seeds and ovary into fruit are collectively termed post-fertilisation events.

Endosperm Formation

- The endosperm is formed during triple fusion. It develops from the central cell of the embryo sac. It is a triploid tissue.
- The cells of the endosperm are filled with reserve food material and are used for the nourishment of the developing embryo.

Types of Endosperm

Nuclear Endosperm

- The endosperm nucleus gives rise to several free nuclei which stay in the peripheral layer.
- A large central vacuole appears in the embryo sac.
- Cell wall formation takes place from the periphery towards the centre leading to the formation of cellular endosperm.
- Examples: Maize, wheat, rice, sunflower

Cellular Endosperm

- Division of the primary endosperm nucleus is immediately followed by cell wall formation so that the endosperm is cellular from the beginning.
- Examples: Balsam, *Datura*, *Petunia*, *Villarsia*

Helobial Endosperm

- A partition wall develops between the two nuclei resulting in the first division of the endosperm.
- A large number of free nuclei are now developed in the upper chamber, while the lower nucleus forms few of them or may not divide at all.
- Examples: *Vallisneria*, *Eremurus*, *Limnophyton*

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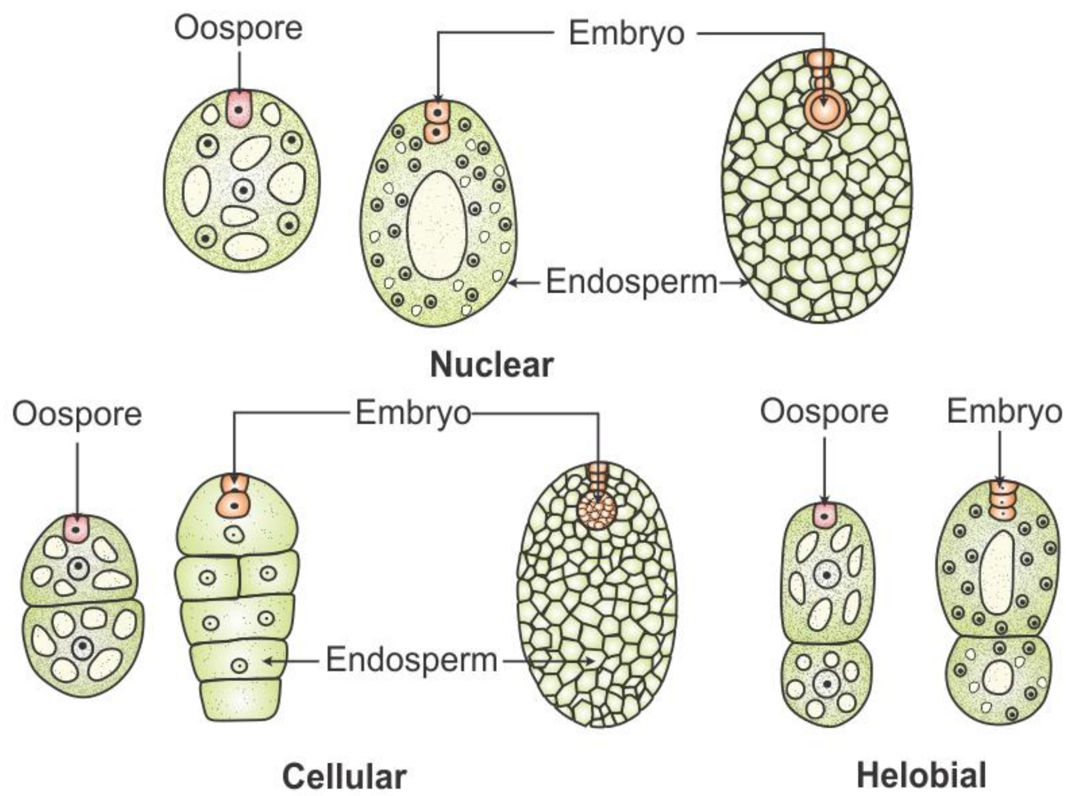

Types of Endosperm

Embryo Formation

- The development of an embryo from a zygote is called embryogeny. The development takes place at the micropylar end of the embryo sac.
- Most of the zygotes divide only after a certain amount of endosperm is formed. This provides assured nourishment to the developing embryo.

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Development of Embryo in Dicots

The zygote divides into two unequal cells - a larger suspensor cell towards the micropyle and a smaller embryonal cell towards the antipodal region.

↓

The suspensor cell undergoes transverse division to form a 6-10-celled suspensor.

↓

The suspensor cell towards the micropylar end is large and is called a haustorium or vesicular cell.

↓

The suspensor cell towards the embryonal cell is called a hypophysis, which forms the radicle tip.

↓

The embryonal cell divides twice vertically and once transversely to produce a two-tiered eight-celled embryo.

↓

The epibasal tier forms two cotyledons and a plumule, while the hypobasal tier produces only hypocotyl and most of the radicle.

↓

The octant embryo undergoes periclinal divisions to produce a protoderm, procambium and ground meristem.

↓

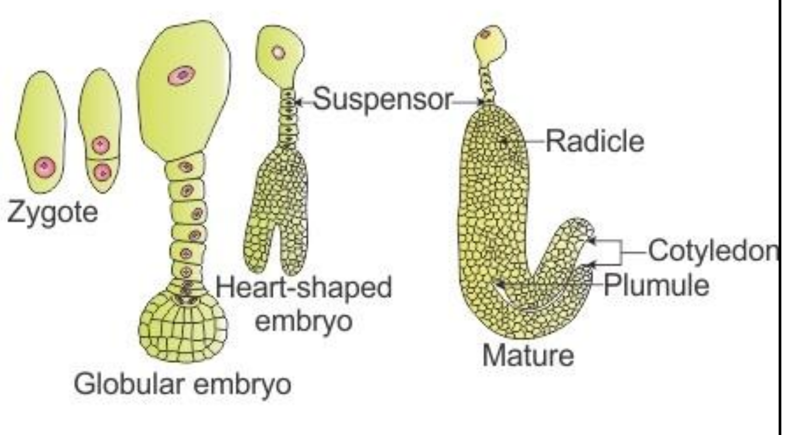
The protoderm forms the epidermis, the procambium forms the stele and the ground meristem produces the cortex and pith.

↓

Initially, the embryo is globular and undifferentiated and is called a proembryo.

↓

It is then transformed into the embryo with the development of radicle, plumule and cotyledons.



Stages in Embryo Development in Dicots

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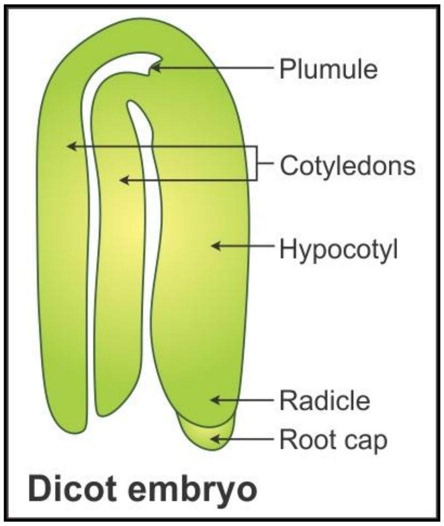
Structure of Dicot Embryo



Development of Embryo in Monocots

The zygote elongates and divides transversely to produce basal and terminal cells.

↓

The basal cell towards the micropylar end forms a large swollen, vesicular suspensor cell. It may function as the haustorium.

↓

The terminal cell divides vertically and transversely to form two cells.

↓

The top cell undergoes a series of divisions to form a plumule and a single cotyledon called scutellum.

↓

The cotyledon grows rapidly and pushes the terminal plumule to one side and lies in a depression.

↓

The middle cell after repeated divisions forms hypocotyl and radicle. It even adds few cells to the suspensor.

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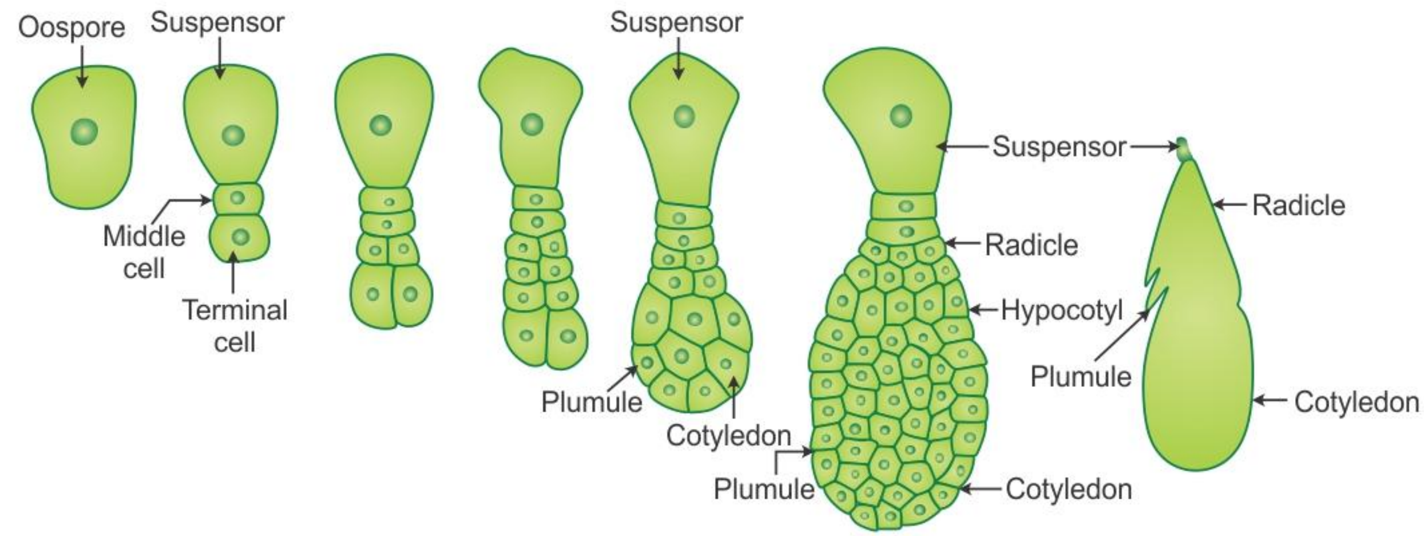
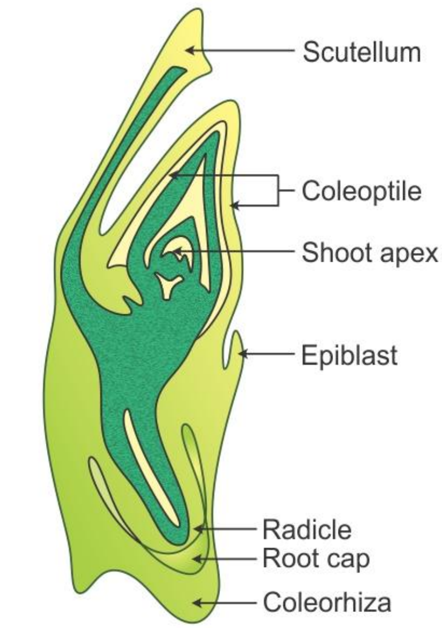


Development of Monocot Embryo

Structure of Monocot Embryo



Monocot embryo

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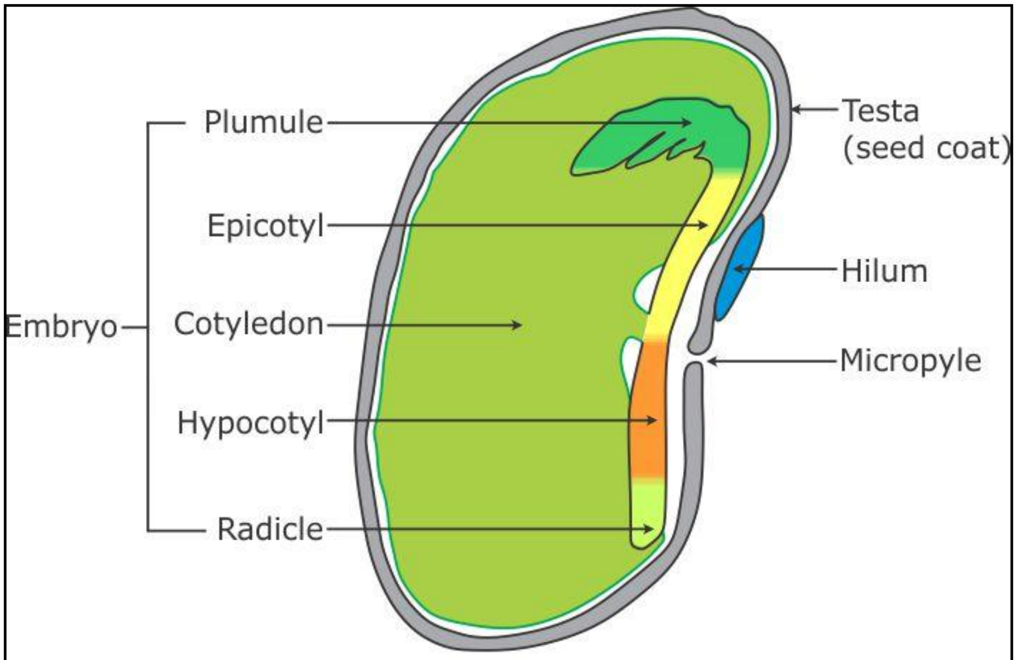
Differences between Dicot and Monocot Embryos

Dicot Embryo	Monocot Embryo
1. Basal cell forms a 6–10-celled suspensor.	1. Basal cell forms a single-celled suspensor.
2. Terminal cell produces the entire embryo except the radicle.	2. Terminal cell produces the entire embryo.
3. The first division of the terminal cell is generally longitudinal.	3. The first division of the terminal cell is generally transverse.
4. It has two cotyledons.	4. It has a single cotyledon.
5. The plumule is terminal.	5. The plumule is lateral.

Seed Formation

- A number of changes occur in the tissue outside the embryo sac leading to the formation of seed.
- The ovule increases greatly in size.
- The integuments dry up. The outer integument becomes hard or leathery and forms the outer seed coat or testa. The inner integument persists and forms the tegmen.
- During development, if the nucellus gets used up, it disappears. If the nucellus persists, it appears in the form of a food-storing thin layer called perisperm.
- The endosperm may either persist or be used up by the embryo before seed formation leaving its remnants.
- A scar is present on the outer seed coat. It is called hilum and marks the point of attachment to the stalk.
- Because of these changes, the ovule finally changes into seed and enters a period of dormancy.



Structure of a seed

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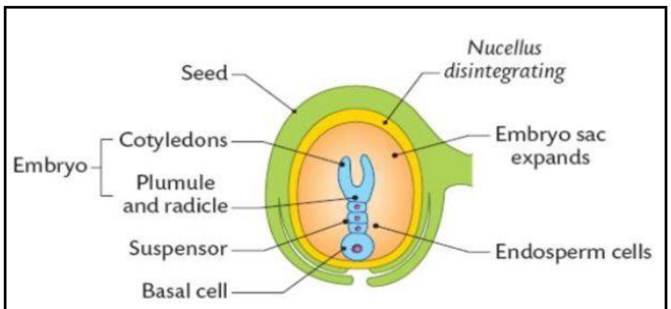
Types of Seeds

Non-endospermic/ Exalbuminous Seeds

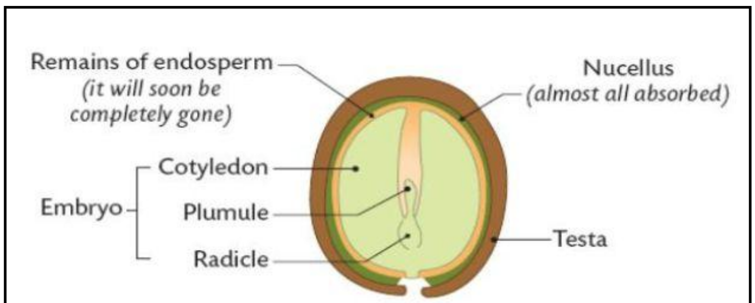
- The endosperm is completely consumed by the developing embryo.
- Examples: Gram, pea, groundnut

Endospermic/Albuminous Seeds

- The embryo does not consume all the endosperm and so, persists in the mature seed.
- Examples: Wheat, maize, barley



Albuminous seed



Exalbuminous seed

Viability of Seeds

- The ability of seeds to retain the power of germination over a period of time is called viability of seeds.
- Seeds may be viable for a few weeks to several years. It is influenced by conditions prevailing during storage and non-germination.
- Loss of viability is due to exhaustion of food around the embryo, damage to the embryo, denaturation of enzymes and premature exhaustion of RNA.
- Viability of some seeds:
    i. *Phoenix dactylifera* – 2000 years
    ii. *Lupinus arcticus* – 10000 years
- Viability of seeds can be detected by two methods:
    i. Ability to germinate
    ii. Testing the ability of seeds to respire

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Importance of Seeds

Dependable

- Pollination and fertilisation of seed plants is independent of water. Therefore, seed formation is more dependable.

Perennation

- Because of the presence of a dormant embryo and a thick protective coat, seeds are more suitable for perennation through unfavourable periods.

Dispersal

- Seeds have adaptive strategies to get dispersed to new habitats and colonise the same.

Reserve Food

- Seeds have reserve food material for the nourishment of young seedlings till they become nutritionally independent.

Variation

- Seeds carry several variations which are essential to adapt to varied environmental conditions.

Storage

- Seeds can be stored for later use for supply of food throughout the year.

Agriculture

- Seeds form the basis of agriculture.

Fruit Formation

- Fruit is the mature or ripened ovary.
- After fertilisation, the ovary begins to enlarge along with the development of seed and finally becomes the fruit.
- The first stimulus for fruit development comes from pollination, the second stimulus is received from the developing seeds and the third stimulus comes from the availability of nutrients.

FACT !

Pollination is essentially involved in fertilisation, seed development, growth of ovary and prevention of ovary abscission.

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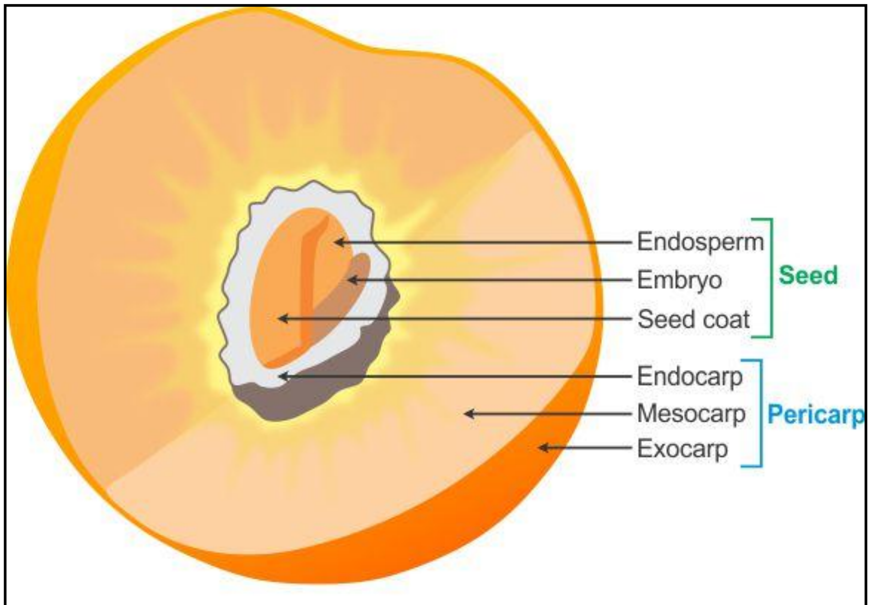
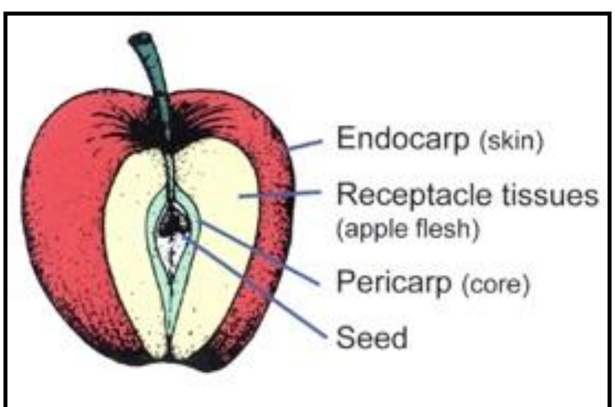
Structure of Fruit



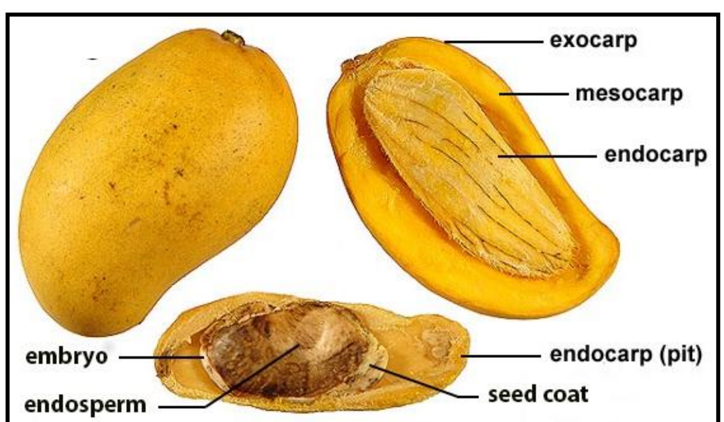
Fruit

Types of Fruits

True Fruits	Only the development of the ovary wall takes place.	Examples: Apple, cashew, strawberry
False Fruits	Thalamus and other floral parts also proliferate along with the development of the ovary wall.	Example: Mango
Parthenocarpic Fruits	These are seedless fruits which develop without fertilisation.	Example: Banana



True Fruit



False fruit

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Significance of Fruit Formation

Protection	•Developing fruits protect the developing seeds from injury, insects and unfavourable climatic conditions.
Dispersal	•Fruits help in the dispersal of seeds to distant places.
Source of Food	•Fleshy fruits act as a source of food for animals. They also act as dispersal agents of their seeds.
Source of Nutrition	•Some fruits provide nourishment to germinating seeds and developing seedlings.
Importance to Man	•Fruits are a source of food, protein, oil, organic acids, vitamins, minerals and sugars.

Apomixis

- Apomixis is the formation of new individuals directly through asexual reproduction without the formation and fusion of gametes.
- Apomixis is of the following types:
  i. **Adventive Embryony (Sporophytic Budding):** The embryo arises from diploid sporophytic cells such as nucellus or integuments. Examples: *Citrus*, *Opuntia*, mango
  ii. **Recurrent Agamospermy:** A diploid embryo sac is formed from the megaspore mother cell which has a diploid egg. The diploid egg grows parthenogenetically into a diploid embryo. The diploid embryo sac can develop directly from either the diploid megaspore mother cell (diplospory) or diploid nucellar cell (apospory). Examples: Apple, pear, *Allium*
  iii. **Non-recurrent Agamospermy:** The embryo develops parthenogenetically from a haploid egg. Example: Banana
  iv. **Apogamy**: A sporophyte or embryo is directly formed from the cells of the gametophyte. Examples: Bryophytes, ferns, lycopods

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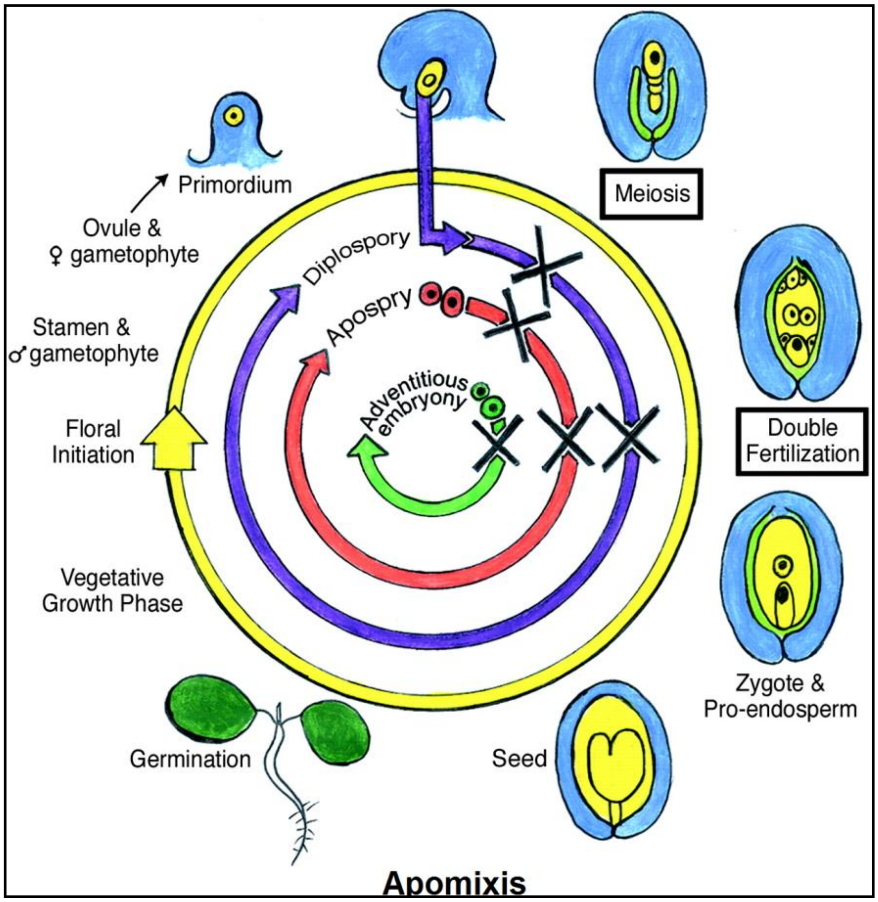

Importance of Apomixis

- The cost of production of hybrid seeds can be minimised if apomixis is introduced in hybrid seeds as apomixis is genetically controlled.
- Adventive embryos are better clones than cuttings.
- Embryos formed through apomixis are generally free from infection.

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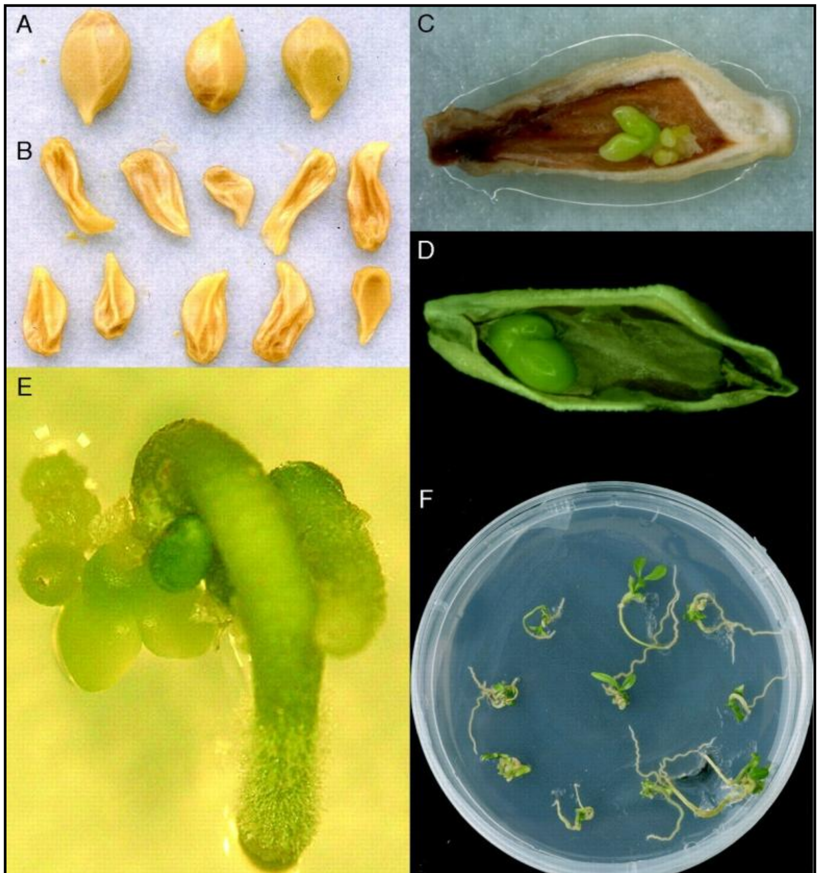
Polyembryony

- Polyembryony is the phenomenon of having more than one embryo in a seed.
- There may be more than one egg cell in an embryo sac or more than one embryo sac in an ovule. All the egg cells may get fertilised.
- Synergids and antipodal cells may also form embryos. It is called mixed polyembryony.
- Occurrence of polyembryony due to fertilisation of more than one egg is called simple polyembryony.
- Formation of extra embryos through sporophytic budding is called adventive polyembryony.
- Polyembryony is mostly observed in onion, groundnut, mango, lemon and orange.
- Citrus seed has 2–40 embryos—one normal and the rest adventive, mostly nucellar.
- The *Allium odorum* seed has 5 embryos—one from the zygote, one from the synergid, two from the antipodal cells and one from the integument of the ovule.



Polyembryony

DID YOU KNOW ?

Polyembryony was discovered by Leeuwenhoek (1719) in *Citrus*.

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