S.Y.B.Sc. Botany CBCS Pattern

BO 241: Plant Anatomy and Embryology

Credit-II Plant Embryology

Chap –11.Endosperm and embryo

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BY

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Endosperm and embryo

- 11.1 Endosperm: Types – nuclear, helobial and cellular.
- 11.2 Structure of Dicotyledonous and Monocotyledonous embryo.

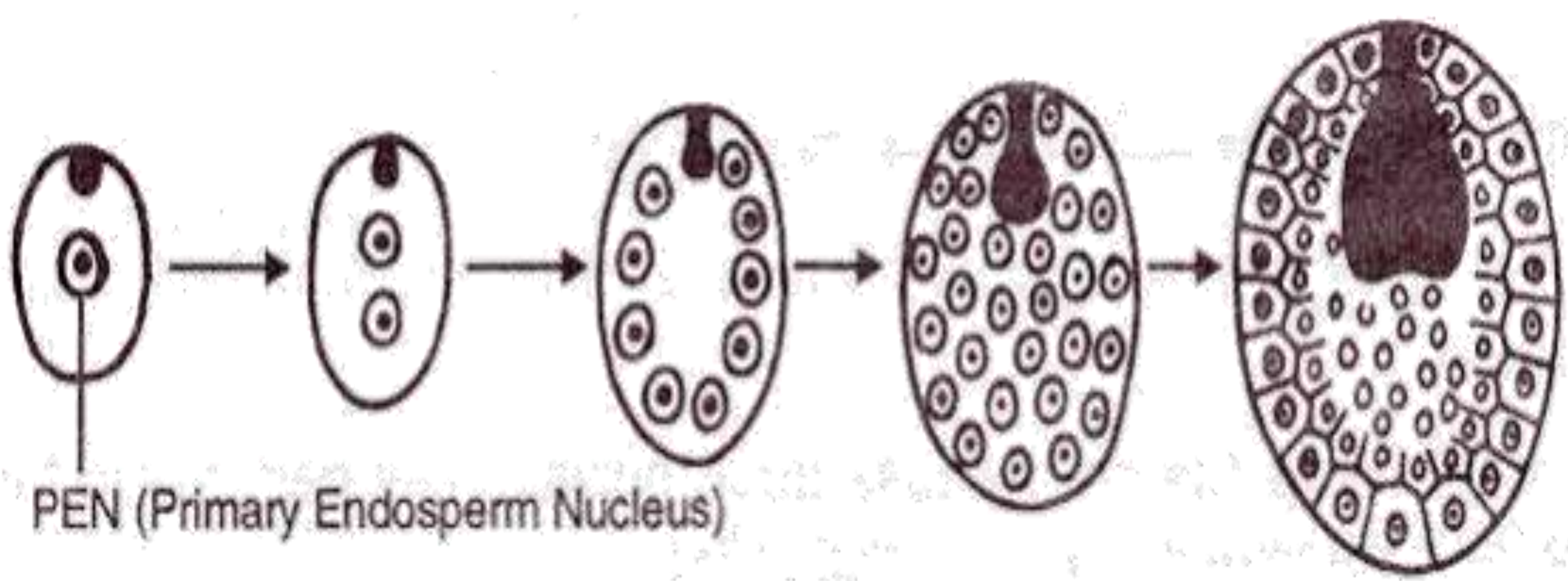
11.1 Endosperm: Types – nuclear, helobial and cellular.

- After fertilization, development of the embryo and the endosperm within the ovule goes side by side. The oospore (zygote), formed as a result of fusion of one male gamete with the egg, develops into the embryo while the primary endosperm nucleus- product of triple fusion, develops the endosperm. The other nuclei or cells within the embryo sac (synergids, antipodal cells) disorganize sooner or later.
- Development of the Endosperm
- The primary endosperm nucleus is a product of triple fusion. This undergoes a series of divisions and ultimately forms endosperm. The Angiospermic endosperm is a triploid (3n) tissue as it is a product of triple fusion. It is formed either by the fusion of one haploid male gamete and one diploid secondary nucleus (fusion product of two haploid polar nuclei) or by the fusion of three haploid nuclei (one male gamete belongs to male gametophyte and two polar nuclei belongs to the female gametophyte).

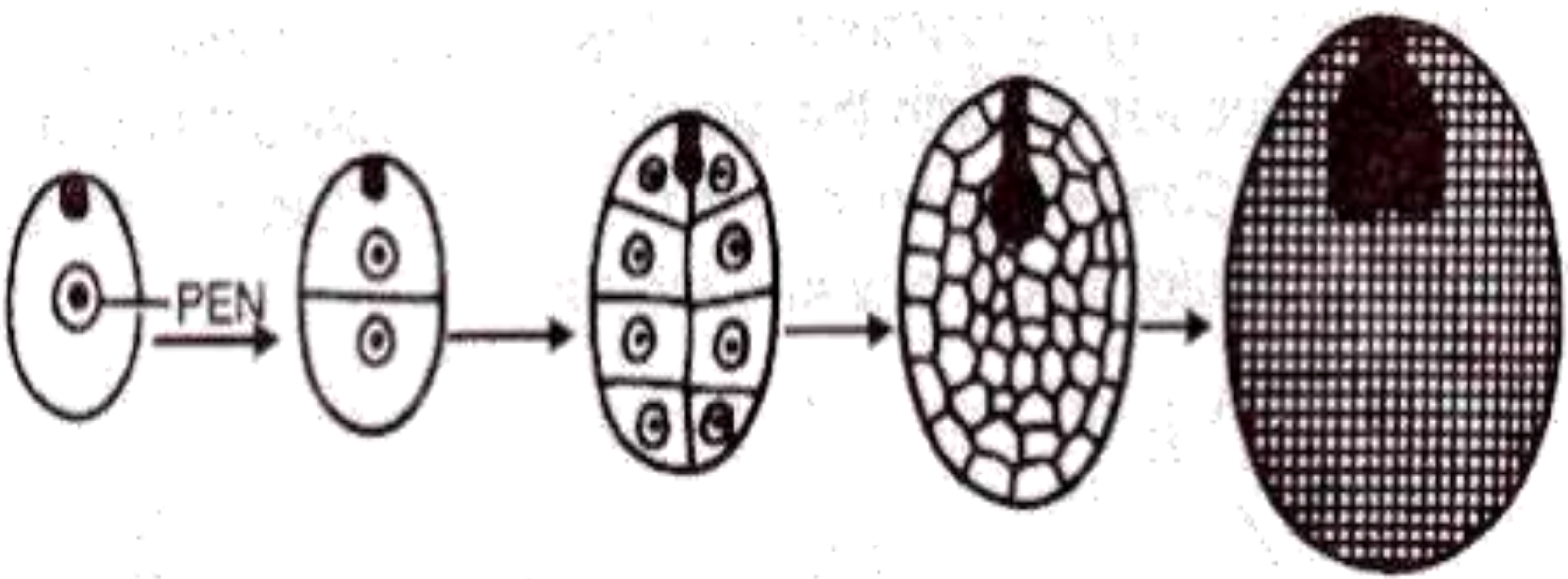
- It is therefore distinct from the endosperm of heterosporous Pteridophytes and Gymnosperms where the endosperm is a simple haploid (n) tissue of the gametophyte not involving any triple fusion like in Angiosperms. Endosperm is a highly nutritive tissue which provides nourishment to the developing embryo.
- In Orchidaceae and Podostemonaceae, the product of double fertilization soon disintegrates and endosperm development is completely suppressed.
- Depending upon mode of development three types of endosperm has been recognized:
- 1. Nuclear endosperm
- 2. Cellular endosperm
- 3. Helobial endosperm
- Of these nuclear endosperm is the most common type which occurs in about 56% families of Angiosperms. It is followed by cellular endosperm (reported in 25% families of Angiosperms) and then by helobial endosperm (reported in 19% families of Angiosperms).

- **1. Nuclear endosperm**
- In this type of endosperm the division of primary endosperm nucleus and number of subsequent nuclear divisions are not accompanied by wall formation and the nuclei thus produced remain free in the cytoplasm of the embryo sac. They remain in the peripheral layer of the cytoplasm surrounding a large central vacuole. Wall formation occurs at later stage around nuclei. The wall formation is mostly centripetal i.e. from the periphery towards the centre and usually begins from the basal periphery e.g. Arachis hypogea.
- In some cases the central vacuole may not be filled up even in the mature seed. This is seen in the palms. Cocus nucifera is the classical example of this type of nuclear endosperm. Development of endosperm in it deserves special mention.
- The primary endosperm nucleus undergoes a number of free nuclear divisions. Then the embryo sac gets filled with a clear fluid (watery liquid endosperm) in which numerous nuclei float. It is known as liquid syncytium.

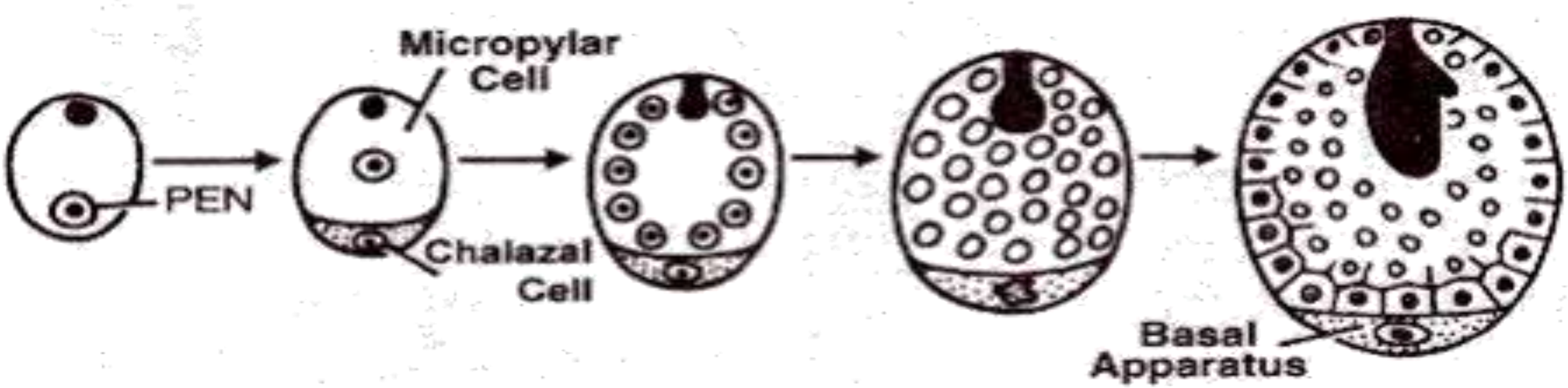
- Gradually nuclei start settling at the periphery with the beginning of peripheral cell wall formation. This forms the coconut meat. In mature coconuts the liquid endosperm becomes milky. The watery endosperm of coconut contains growth promoting „coconut milk factor" and that is why it is used as a nutrient medium in plant tissue culture experiments. Nuclear endosperm is commonly found in polypetalous dicotyledons



- **2. Cellular endosperm**
- In this type of endosperm, division of the primary endosperm nucleus is immediately followed by wall formation so that the endosperm is cellular from the beginning. The first wall is laid down transversely but thesubsequent divisions are irregular. Adoxa, Peperomia, Villarsia etc. are some common examples.



- **3. Helobial endosperm**
- Among members of Helobiales (e.g. Vallisneria, Eremurus, Limnophyton etc.) there is type of endosperm the development which is intermediate between the nuclear and the cellular type. Here the first division of the primary endosperm nucleus is accompanied by the formation of transverse wall. This divides the embryo sac unequally into two compartments - a small chalazal chamber and a large micropylar chamber. This step is followed by free nuclear division in both the chambers but there are relatively more free nuclear divisions in micropylar chamber in comparison to chalzal one. The chalazal chamber often degenerates. The free nuclear divisions in the micropylar chamber are followed by wall formation and thus a cellular endosperm tissue is formed and usually found in the members of the order Helobiales



It is the endosperm, on the basis of which seeds can also be categorized into two categories.

- 1. Non-endospermic seeds
- 2. Endospermic seeds
- **1. Non- endospermic seeds** (ex-albuminous seeds)
- In plants where the entire endosperm consumed or utilized in the nutrition of the developing embryo, the mature seeds thus formed are without endosperm. Such seeds are termed as non-endospermic seeds. Example are seeds of beans, peas etc. The non-endospermic seeds store their food material in cotyledons.
- **2. Endospermic seeds** (albuminous seeds)
- In plants where the seeds retain endosperm even at maturity and do not consumed or utilized the endosperm completely in the nutrition of the developing embryo. Such seeds are said to be endospermic seeds. Example are seeds of coconut, castor etc. The endosperm present in the seed is utilized after germination in the establishment of young seedlings.

Development of the embryo

- The process of development of mature embryo from diploid oospore/zygote is called embryogenesis.

- In all Angiosperms the embryogenesis starts with the division in **oospore** and it divides to develop a two-celled proembryo by forming a transverse wall. The cell near the micropyle is termed the basal cell and the cell facing towards the centre of the embryo sac is called the terminal cell. The basal cell forms the **suspensor** and may or may not contribute in rest activities so sometimes called as suspensor cell, whereas terminal cell is responsible for further development of embryo so called embryo cell.

- Types of embryo development

- On the basis of plane of division of the terminal cell (also known as apical or embryo cell) in the 2-celled proembryo and the contribution of the basal cell and terminal cells in the formation of embryo proper, six types of embryogeny (embryo development) have been reported by Johansen (1950) among the Angiosperms.

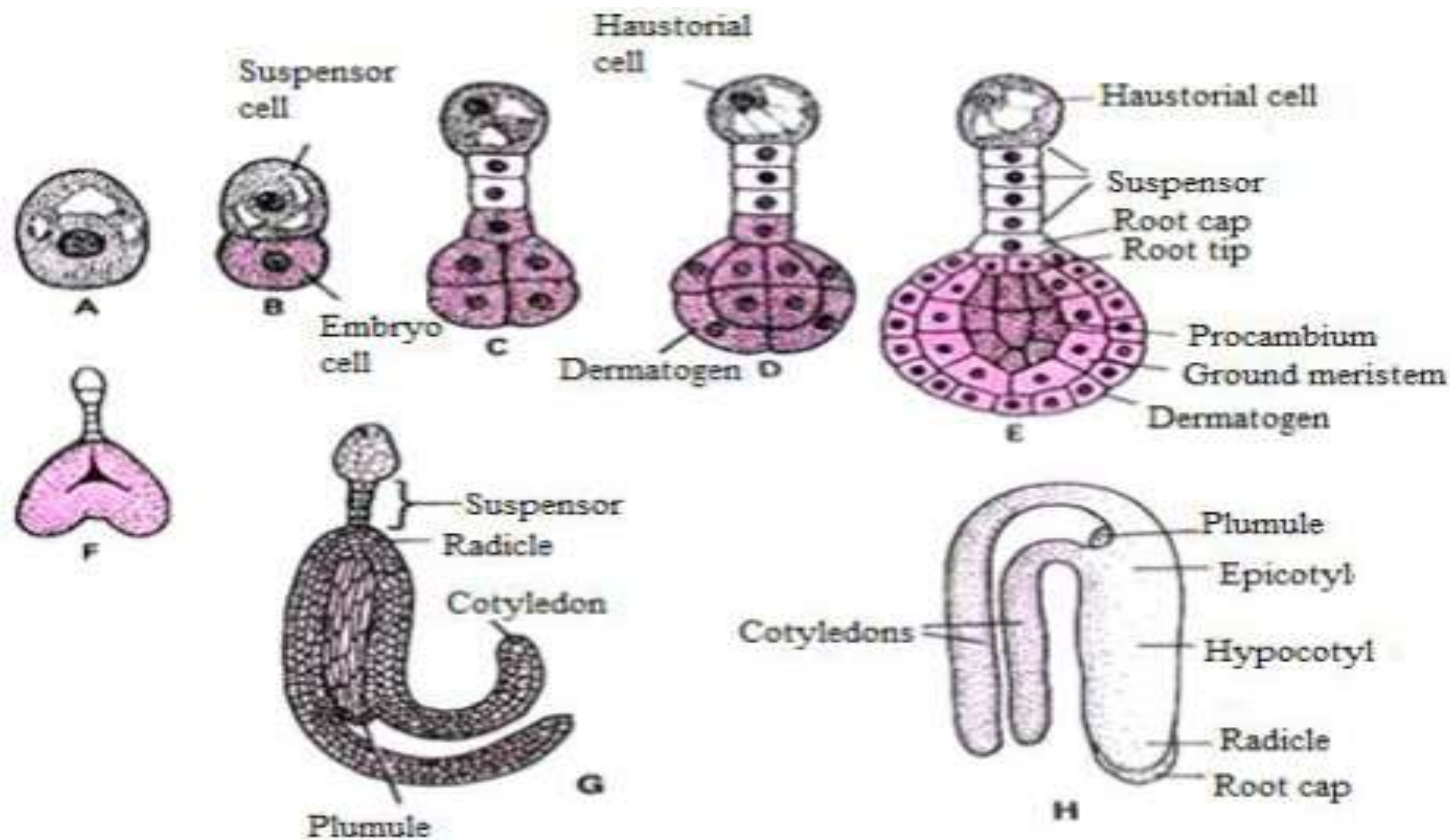
- 1. Onagrad or Crucifer type (e.g. Annonaceae, Brassicaceae, Onagraceae, Pedaliaceae, Ranunculaceae, Scrophulariaceae).
- 2. Asterad type (e.g. Asteraceae, Balsamianceae, Violaceae, Vitaceae).
- 3. Solanad type (e.g. Campanulaceae, Linaceae, Solanaceae, Theaceae).
- 4. Caryophyllad type (e.g. Caryophyllaceae, Crassulaceae,Haloragaceae).
- 5. Chenopodiad type (e.g. Boraginaceae, Chenopodiaceae).
- 6. Piperad type (e.g. Loranthaceae, Piperaceae).

Development of dicotyledonous embryo

- The classical example is Capsella bursa-pastoris (shepherd's purse) of Brassicaceae. The ovule is campylotropous so that the embryo sac and the later developed endosperm as well as embryo are horseshoe-shaped. Here the development of embryo is **Onagrad or Crucifer type**.
- 1. Zygote (oospore) divides transversely. As a result of this a two-celled proembryo is formed.
- 2. The larger basal cell at the micropylar end is called suspensor cell. The smaller one, away from it termed as terminal cell or embryo cell.
- 3. The suspensor cell divides transversely a few times to produce a filamentous suspensor of 6-10 cells. The suspensor helps in pushing the embryo in the endosperm.
- 4. The first cell of the suspensor (towards micropyle) becomes swollen and called haustorium or vesicular cell.
- 5. The last cell of suspensor (towards embryo cell) is known as hypophysis. It forms radicle and root cap.

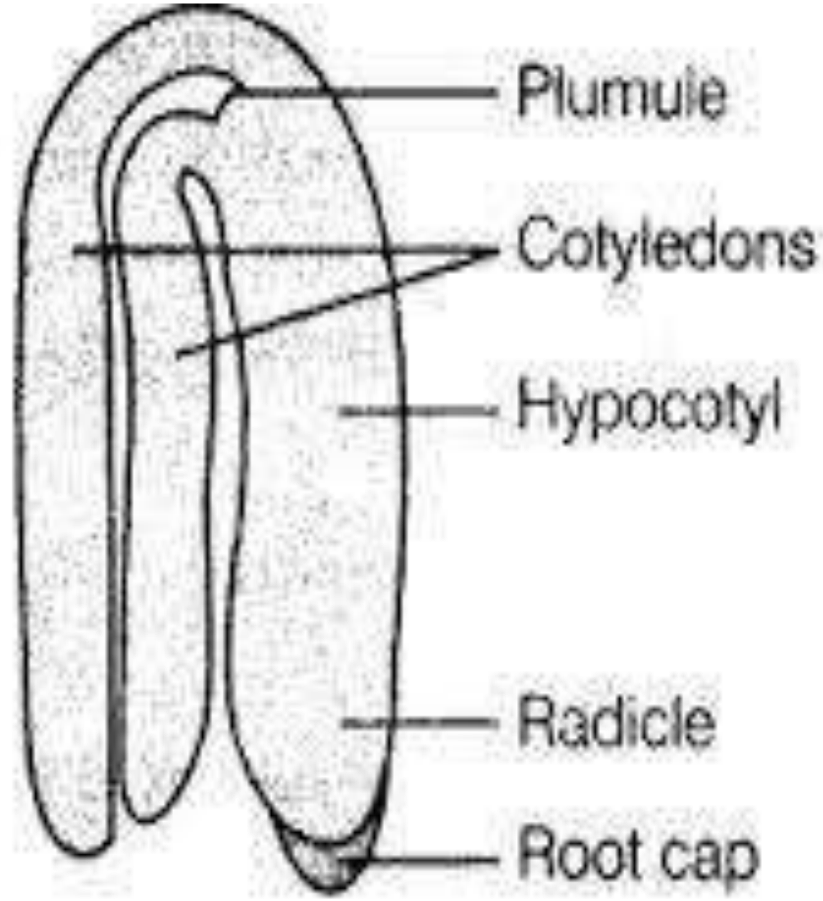
- 6. The embryo cell undergoes two vertical divisions and one transverse division to form quadrant and then octant stage. In octant, eight cells arranged in two tiers- epibasal (terminal) and hypobasal (near the suspensor). The epibasal cells eventually form the two cotyledons and the plumule. The hypobasal cells produce the hypocotyl. For this the octant embryo undergoes periclinal divisions producing outer layer of protoderm, procambium and ground meristem. Protoderm forms epidermis, procambium gives rise to steal or vascular strand and ground meristem produces cortex and pith. It is initially globular but with the growth of cotyledons it becomes heart-shaped and then assumes the typical shape, e.g., Capsella bursa-pastoris.

Stages in the development of a dicot embryo; A. Zygote or oospore; B. Division of zygote into suspensor and embryo cells; C. Formation of suspensor and embryo octant; D. Pericinal divisions of embryo octants to form outer dermatogens; E. Globular embryo showing regions ofradical, procambium, ground meristem and dermatogens; F. Heart-shaped embryo; G. Maturedicot embryo; H. A typical dicot embryo



Structure of Dicot Embryo

- The mature embryo consists of an embryonal axis having **two cotyledons.** Embryonal axis above the level of cotyledons forms the **plumule** (epicotyl) and below the cotyledons, the **radical** (hypocotyl). Upon germination the plumule forms the shoot and the radical gives rise the root system. The reserve food material in the cotyledons is used in the establishment of young seedlings

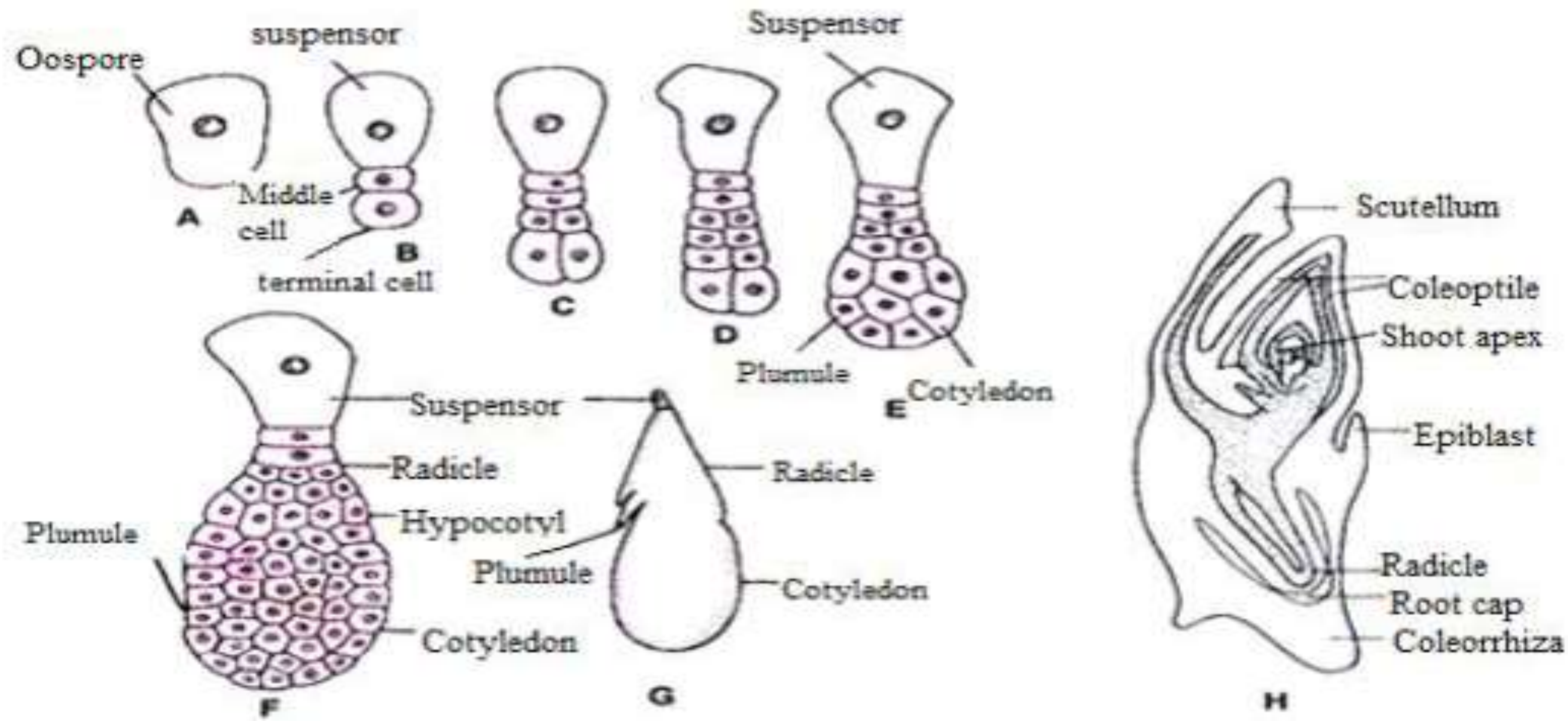


A typical dicot embryo

Development of monocotyledonous embryo

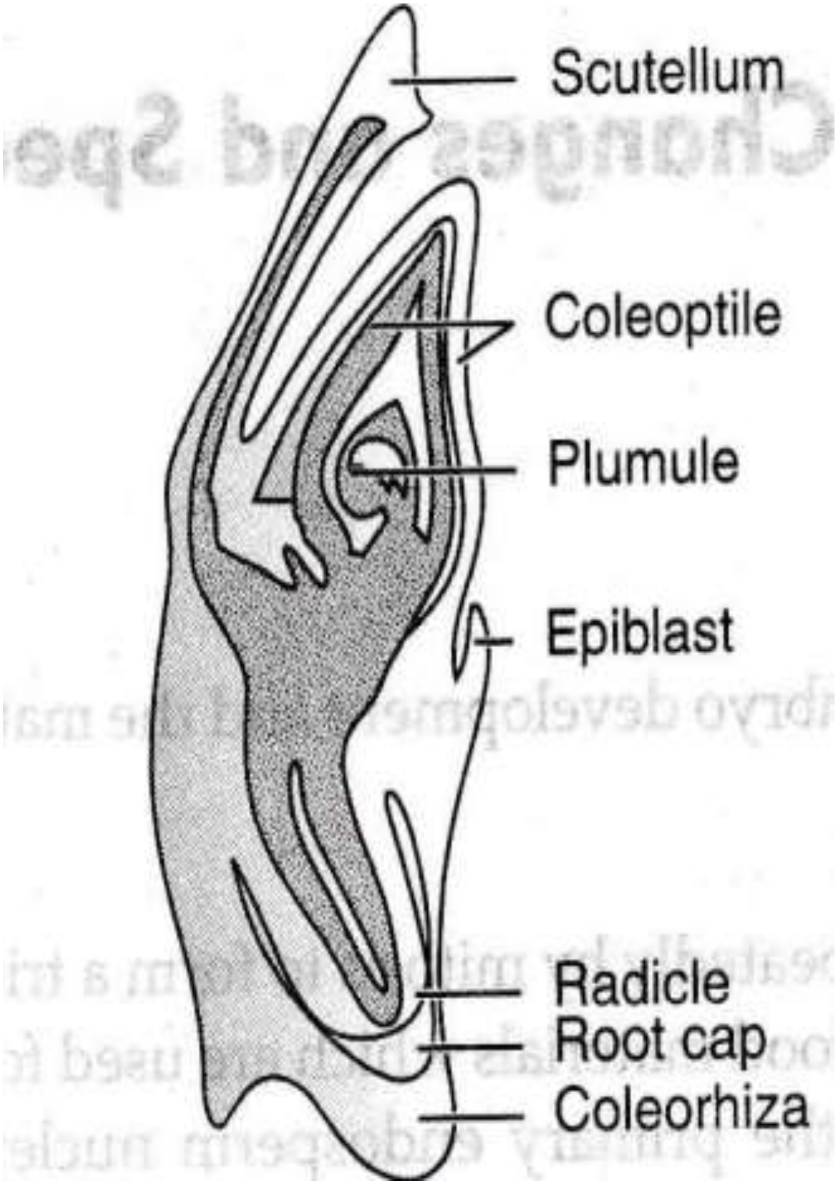
- There is no essential difference between the embryogeny of monocotyledons and that of dicotyledons but as a single cotyledon develops instead of two from the embryo in monocotyledons, there is some difference in later stages. We are taking an example of Luzula forsteri of Juncaceae for describing the development of monocotyledonous embryo. Here the development of embryo is also **Onagrad or Crucifer type.**
- The early development of dicot and monocot embryos are similar upto octant stage. Later on differentiation starts.
- 1. The zygote or oospore elongates and then divides transversely to form basal and terminal cells.
- 2. The basal cell (towards micropylar end) produces a large swollen, vesicular suspensor cell. It may function as haustorium.
- 3. The terminal cell divides by another transverse wall to form two cells.
- 4. The top cell after a series of divisions forms plumule and a single cotyledon.

- 5. Cotyledon called scutellum, grows rapidly and pushes the terminal plumule to one side. The plumule comes to lie in a depression.
- 6. The middle cell, after many divisions forms hypocotyl and radicle. It also adds a few cells to the suspensor.
- 7. In some cereals both plumule and radicle get covered by sheaths developed from scutellum called coleoptile and coleorhiza respectively.



Structure of Monocot Embryo

- The embryos of monocotyledons have only one cotyledon. In grass family (Poaceae), this cotyledon is called **scutellum**. It is situated towards lateral side of embryonal axis. This axis at its lower end has **radicle** and root cap enclosed in a sheath called **coleorhiza** . The part of axis above the level of attachment of scutellum is called **epicotyl.** It has shoot apex and few leaf primordia enclosed in a hollow foliar structure called **coleoptile**. Epiblast represents rudiments of second cotyledon.



Reference

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