PAGE NO.
DATE: / /200

ROLE OF EMBRYOLOGY IN TAXONOMY

The role of embryology in taxonomy was brought to prominence by the famous German embryologist Schnarf in 1931. Often a single embryological character can mark out the family
eg × Pseudoembryo sac in Podostemaceae
× Composite endosperm in Loranthaceae
× Formation of a single pollen grain from a pollen mother cell in the Cyperaceae.

Embryological characters which have proved of special importance in Taxonomic Considerations

1. Anther - No. and arrangement of loculi; the tapetum is glandular or amoeboid.
2. Quadripartition of the microspore mother cell - whether div. is successive or simultaneous; whether quadripartition takes place by furrowing or by formation of cell plates; whether the microspores become seperated or remain together in tetrads or larger masses.
3. Pollen grains - No. and position of the germ pores; sculpturing pattern of the exine etc.
4. Development and structure of the ovule - Crassinucellate or tenuinucellate, number of the integuments; presence of aril, carucle, obturator, place of its origin etc.
5. Origin and extent of the sporogenous tissue in the ovule - The archegonium is one-celled or many celled.
6. Megasporogenesis and development of the embryo sac - shape of the megaspore tetrad, position of the functional megaspore tetrad; whether embryosac is monosporic, bisporic, tetrasporic etc.
7. Form and organisation of mature embryo sac - No. and arrangment of the nuclei and the

PAGE NO.
DATE: / /200

cells formed from them; persistence and/or early disappearance of the antipodal cells; formation of embryosac haustoria.

8. Fertilization - Path of entry of pollen tube into the ovule.
9. Endosperm - Nuclear, Cellular, or Helobial; presence and absence of endosperm haustoria and the manner in which they are formed, when present.
10. Embryo - Form and organisation of the mature embryo; presence and absence of suspensor haustoria.
11. Seed coat - Its' development and the contribution of the integuments in its organisation, especially when structures such as aril, caruncle, operculum and sarcotesta are present.
12. Special features - Apomixis, polyembryony etc.

Some families especially marked out by their embryological features

I PODOSTEMACEAE

It includes perennial, aquatic herbs which grow attached to stones in running water. Because of their peculiar morphological features, earlier workers regarded them as algae, lichen, liverworts or even mosses. This family is restricted to the tropics.

A unique feature of this family is the formation of pseudoembryo sac due to the disintegration of the nucellar cells below the embryo sac. Fig 1a A combination of the following embryological characters further mark out this family.

PAGE NO.
DATE: / /200

1. Occurrence of pollen grains in pairs Fig 1b
2. Bitegmic, tenuicellate ovule with the micropyle formed by the outer integument. Fig 1a.
3. Bisporic embryo sac.
4. Solanad type of embryogeny.
5. Prominent suspensor haustoria Fig 1c
6. Absence of antipodal cells (except in Dicraea)
7. Absence of triple fusion and consequent endosperm.

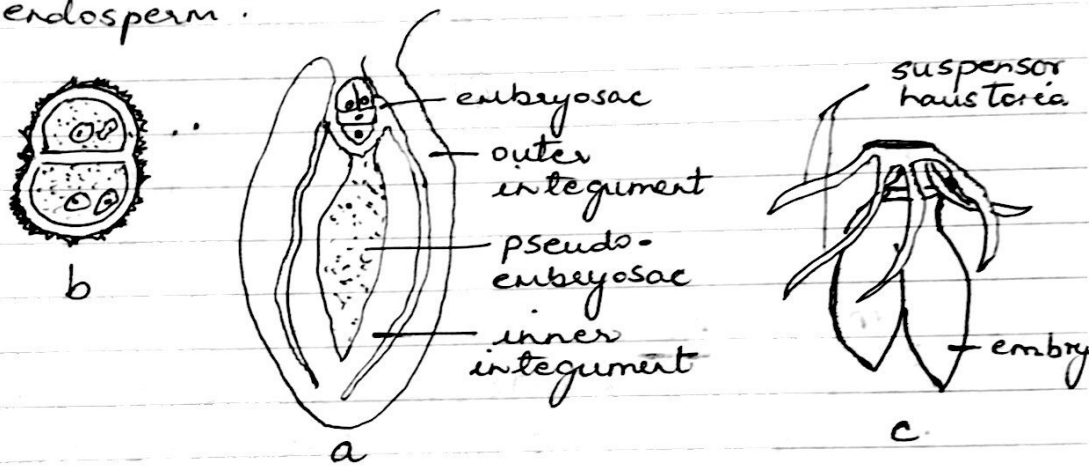


Fig I a, b, c.

II ONAGRACEAE:

A characteristic feature of this family is the Oenothera type of embryo sac, which is not found in any other family except as an abnormality. The embryo sac is of the oenothera type and is derived from the micropylar megaspore of the tetrad. The lower three megaspores do not disappear. They persist at the base of the mature embryo sac Fig 2
The two nuclei formed after the first nuclear division in the functional megaspore remain together at the micropylar end of the cell. As a result of second mitosis four nuclei are formed at the micropylar end. Of these

three nuclei organise into an egg apparatus and the fourth one function as the only polar nuclei. There are no antipodal cells.

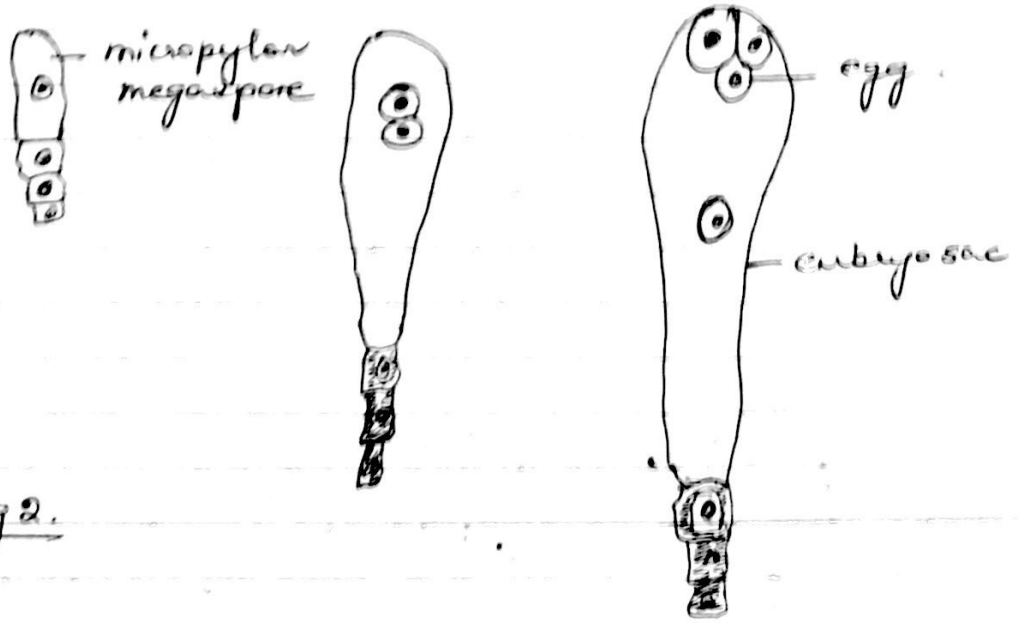


Fig 2.

III CYPERACEAE

In flowering plants, as a rule each monosporic microspore mother cell gives rise to four functional microspores. However in cyperaceae, only one pollen grain is formed by each microspore mother cell. Following meiosis in the microspore mother cell three microspore nuclei are cut off on one side and they do not form pollen grains Fig 3. The fourth nucleus undergoes mitosis to form a vegetative cell and a generative cell. The latter undergoes another mitosis forming to sperm cells.

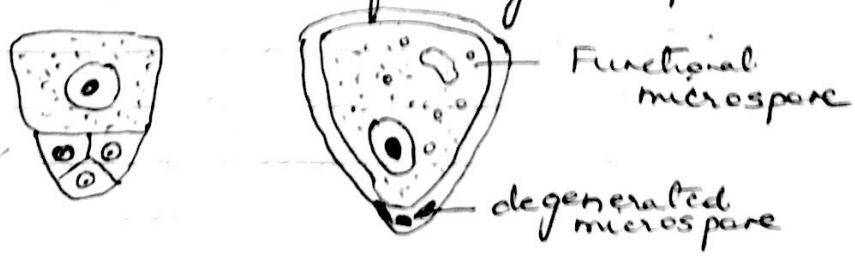


Fig. 3.

Outside Cyperaceae, some members of Epacridaceae show the degeneration of three of the four microspores. The cyperaceae can be marked out from

these taxa in having 3-celled pollen, members of the Caryophyllaceae shed pollen at the 2-celled stage.

Application of Embryological data in Taxonomy

I ABOVE THE FAMILY LEVEL.

It should be noted in the first instance that the delimitation of angiosperms as a whole largely depends on embryological characters. Enclosed ovules that are mostly anatropus, polygonum type of embryosac in majority of flowering plants, double fertilization and triple fusion and post fertilization development of polyploid endosperm are some of the embryological features which not only characterise the whole group of angiosperms but also support its probable monophyletic origin. Further, the most primary classification of the sub division Angiospermae into two classes — Monocotyledonae and Dicotyledonae is based on the characteristic of embryo, which are constant for the group. The exceptions however only prove the rule.

1. Quite a few order of angiosperms are morphologically well defined and also exhibit a set of uniform embryological features. Caryophyllales or more widely known as Centrospermae are embryologically very distinctive. They characteristically have trinucleate pollen, Campylotropus or amphitropus, bitegmic crassinucellate

ovules, commonly with the inner integument longer than the outer and very often with a space between the integuments towards the chalazal end. The seed has a curved, peripheral embryo, more or less surrounding the food storage tissue which consist mainly of perisperm, with little or no endosperm. According to Cronquist (1968), no plants outside the order are known to present this combination of characters.

2. Ericales are a homogenous group of Sympetalous families in which most of the members share a long series of embryological features, notably the production of pollen in tetrads.

3. Gentianales differ from other sympetalous orders in having mostly simple and opposite leaves, well developed internal phloem and lack of integumentary tapetum. They also have a nuclear endosperm.

4. The Monocotyledonous order Helobiae is characterised by Helobial type of endosperm.

5. The order Orchidales is characterised by undifferentiated embryo and very little or no endosperm.

II. AT AND BELOW THE FAMILY LEVEL

Certain families and genera once regarded to have a doubtful systematic position, have now been ascribed their proper placements with supporting embryological evidence.

1. CACTACEAE

Members of the family cactaceae present a large no. of variable characters and thus were treated variously by different authors. Wettstein (1935) regarded them under Centrospermae and this has been supported embryologically (Mauritzon 1934, Newmann 1935) as well as on the basis of Phytochemistry. Cactaceae agree with the rest of the centrospermae in possessing the following embryological characters.

(i) anther tapetum glandular and its cells 2-4 nucleate.
(ii) Division of microspore mother cell simultaneous
(iii) Pollen grain trinucleate.
(iv) Ovules campylotropus with strongly curved and massive nucelli
(v) micropyle formed by the swollen apex of the inner integument which protrude out and approach the funiculus.
(vi) formation of nucellar cap
(vii) functioning of the chalazal megaspore of the tetrad
(viii) formation of monospore 8-nucleate embryosac.
(ix) functioning of the perisperm as the chief storage region.

2. ONAGRACEAE

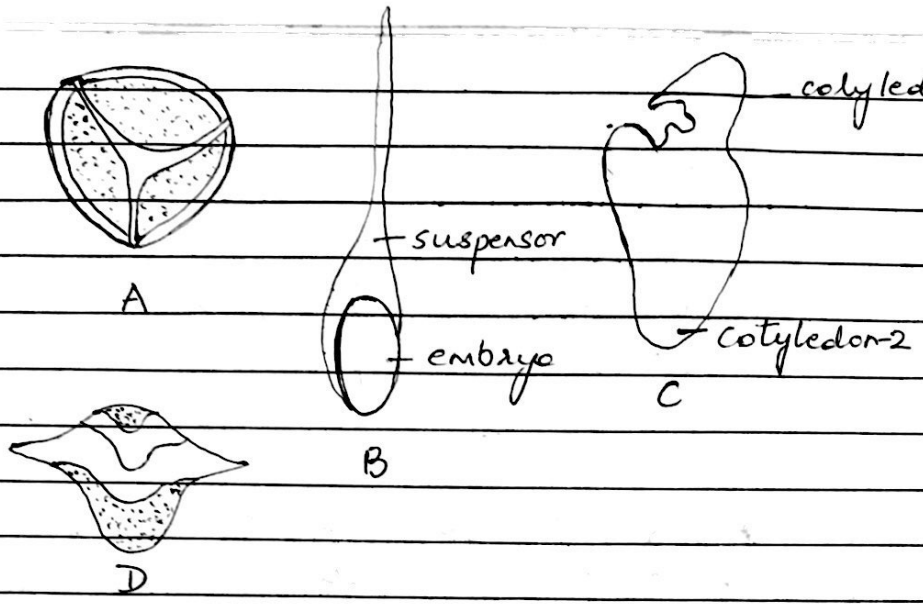
The family onagraceae is characterised by the peculiar monosporic 4-nucleate embryosac in all its genera except Trapa. This genus has been placed variously by different systematists —

(I) under Onagraceae (II) as an isolated member of Haloragaceae and

(III) as the only genus of the monotypic family Trapaceae.

Embryological evidence (Ram, 1956) support the view that Trapa should be removed from Onagraceae to Trapaceae.

Features	Trapa	Onagraceae
1. Pollen grain	Pyramval with three much folded meridional crest - A	Bluntly triangular and basin shaped.
2. Ovary	Biloculav with a single pendulous anatropus ovule in each chamber.	Triloculav with many ovules/chamber on an axile placenta.
3. Embryosac	Polygonum type	Oenothera type
4. Endosperm	Absent	Present - Nuclear
5. Embryo	Solanad type	Onagrad type
6. Suspensor	well developed - suspensor haustorium - B	short & inconspicuous
7. Cotyledons	One cotyledon extremely reduced - C	Cotyledons equal
8. Fruit	large, one-seeded drupe with prominent spines - D	Loculicidal capsule.

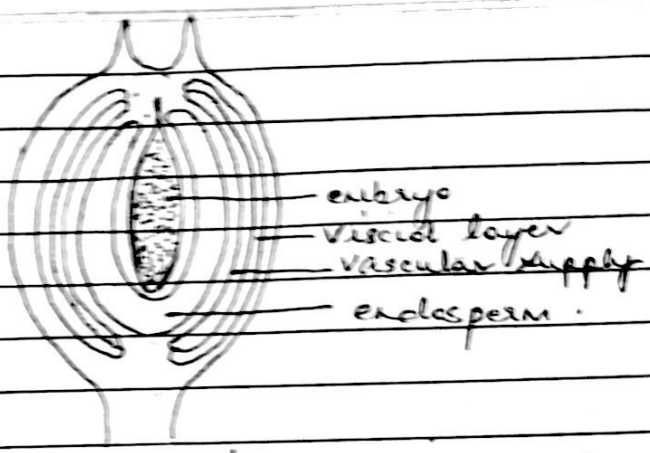


Embryology of Trapa – Fig A – D.

3. LORANTHACEAE

The two sub-families, Loranthoideae and Viscoidae show significant differences in their floral structure, embryosac and endosperm development, embryogeny and location of vascular supply with respect to the viscid layer in the fruit.

Features	Loranthoidae	Viscoidae
1. Pollen	Triradiate	Spherical
2. Embryosac	Polygonum type – monosporic	Allium type – bisporic
3. Endosperm	Composite	Not composite
4. Div. of Zygote	Vertical 	Transverse sometimes vertical
5. Suspensor	Present	Absent
6. Polyembryony	Present	Reported only in Embrachion
7. Fruit	Viscid layer outside the vascular supply	Viscid layer inside the vascular supply



These embryological differences strongly suggest raising of the two sub-families to the rank of families. Maheshwari (1964) have proposed that, as suggested by Mees, the name Loranthaceae be retained for the sub-family Loranthoideae and Viscaceae for the sub-family Viscoideae. (Bhandari & Vohra 1983; Bhatnagar & Johri 1983)

4. PAEONIA

In most of the classical systems of the angiosperm classification the genus Paeonia is kept under the monogeneric tribe Paeonieae of the Ranunculaceae (Tyagi, 1970). However, many authors have pointed out that Paeonia is distinct from Ranunculaceae in its features of vascular anatomy, floral anatomy, basic chromosome number and size and morphology of the chromosomes.

Embryological data also support the view of removing Paeonia from the Ranunculaceae to a separate family Paeoniaceae. The most peculiar embryological feature of this genus is its embryogeny. According to

Yakovlev and Yoffe the zygote nucleus undergoes repeated nuclear divisions forming a coenocytic structure. Later, the nuclei become lodged in peripheral layer of cytoplasm, around a large central vacuole. Now wall formation occurs and the coenocyte becomes cellular except in the central part. Some of the peripheral cells give rise to embryo initials of which only one matures into adult embryo. However, acc. to Murgai (1962) the first division of the zygote nucleus is followed by wall formation and the coenocyte is derived from the basal cell of the 2-celled proembryo. The subsequent development of the embryo from the coenocyte is essentially the same as described by Yakovlev and Yoffe. Other embryological features which justify the separation of Paeonia from Ranunculaceae to a separate family are —

Feature	Paeonia	Ranunculaceae
1. Stamen	Spirally arranged-centrifugal	Spirally arranged-centripetal
2. Anther	Multilayered endothecium	One layered endothecium
3. Female archesporium	Multicelled, many megaspore mother cells functions	One cell functions
4. Embryogeny	Unique	Onagrad or rarely Solanad type
5. Seed	Arillate	Non-arillate
6. Fruit	Follicle	Achene

5. EXOCARPUS

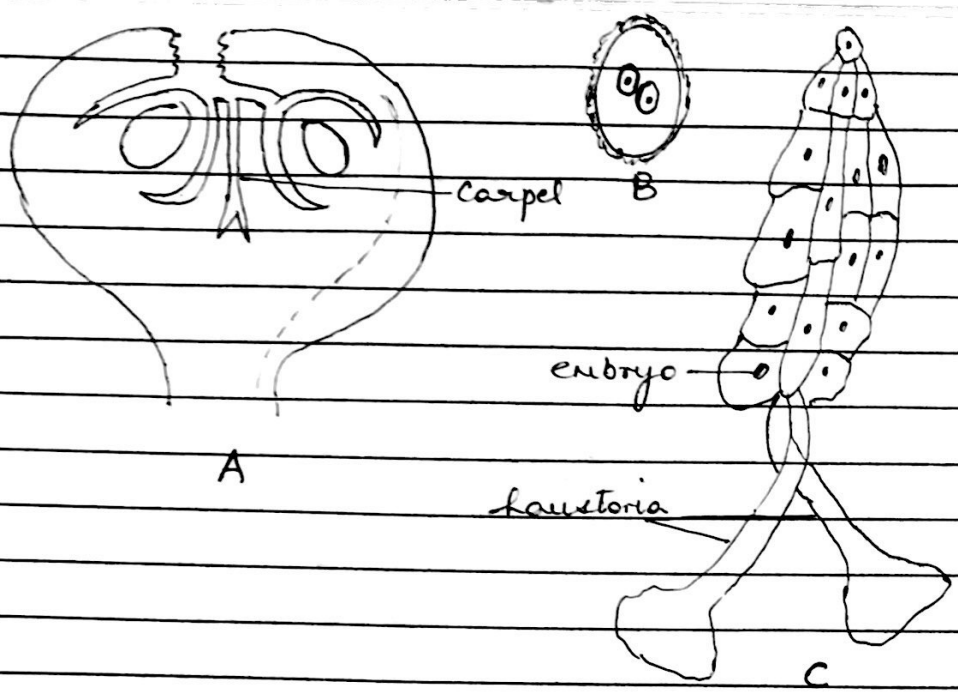
Gagnepain and Boureau (1947) suggested that Exocarpus should be removed from the Santalaceae and kept in a seperate family Exocarpaceae near Taxaceae, under Gymnosperms. They based their suggestions on the following characters of the genus.

(i) Articulate pedicel
(ii) Naked ovule
(iii) Presence of pollen chamber.

The simple structure of ovule led Lam (1948) to place it in the protangiospermae, alongwith Salix and Casuarina.

Ram (1959) studied the embryology of three species of Exocarpus namely E. cupressiformis, E. spartens and E. stricta. Her main observations are as follows -

(I) The flower shows the usual angiospermous structure. - A
(II) Pollen grains are shed at the 2-celled stage. - B
(III) Embryosac is of Polygonum type.
(IV) The endosperm is cellular. It has a 2-celled chalazal haustorium in E. stricta and a multicellular haustorium in E. cupressiformis
(V) Division of zygote is transverse. Further transverse divisions give rise to a long filamentous embryo - C



CONCLUSION

There are several other notable examples which embryological characters have rendered in the solution of taxonomic problems. It has been seen that embryological data has provided sufficient evidences in solving interrelationships of families and genera. Although it is not claimed that these data will always prove important, they should form a part of any thorough taxonomic analysis.