E-RESOURCE

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Class: B.Sc. –Botany

Year: II, Paper: I, UNIT: II

Topic: Introduction to Taxonomic Evidences from Palynology

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A natural system of classification should be based on the analysis and harmonization of evidence from all organs, tissues and parts.

Traditionally, plant taxonomy has been mainly dependent upon comparative external morphological characters.

Morphological characters of plants have been used extensively both for classification and for diagnostic purposes and they are still indispensable to the taxonomists.

However, **external morphology study alone is not adequate and other branches of study are of considerable value in proper assessment of the systematic status of a taxon and its phylogeny.**

Thecontributions to systematics can come from any branch of botany viz.,**Anatomy, Palynology, Cytology, Embryology, Phytochemistry, Chemotaxonomy, Molecular Systematics** and they have played significant role in plant taxonomy.

PALYNOLOGY(Palynology in relation to Taxonomy)

PALYNOLOGY IS THE STUDY OR SCIENCE OF POLLEN GRAINS AND SPORES.

[Palynology is the science which deals with Pollen Grains].

The term Pollen is derived from Greek verb **PALYNEIN** means **"to scatter"**.

PALYNOLOGY IS THE SCIENTIFIC STUDY OF PLANT POLLEN AND SPORES.

PALYNOLOGY IN RELATION TO TAXONOMY

1. SPECIES IDENTIFICATION:Pollen grains and Spores have unique characteristics that can be used to identify plant species. Palynologists examine these microscopic structures to differentiate between different plants, adding in the classification of species.
2. TAXONOMIC MARKERS:Pollen morphology, including size, shape, and ornamentation, can serve as taxonomic markers. These features help in grouping plants into families, genera and species, contributing to the overall taxonomy of plants.
3. FOSSIL RECORD: Palynology is crucial for studying ancient plant life through the analysis of fossilized pollen and spores. It helps in reconstructing the evolutionary history of plants and their relationships, which is fundamental to taxonomy.
4. ENVIRONMENTAL CONTEXT: Palynology also has applications in environmental and ecological studies. By identifying the pollen in sediments or soil samples, scientists can reconstruct past environments and assess the impact of environmental changeson plant communities.
5. BIOSTRATIGRAPHY: In paleontology and geology, the presence of specific pollen types in sediment layers is used for biostratigraphy, which is a technique for dating and correlating rock formations. This stratigraphic information is important in understanding the history and distribution of plant taxa.

In summary, palynology provides valuable data and insights that assist taxonomists in the classification and categorization of plant species, both living and extinct, and contributes to a better understanding of plant evolution and environmental history.

Pollen grains are used as experimental material in biological investigations to resolve the problems related to classification.

Description of the fundamental features of pollen morphology by early botanists has demonstrated the potential value of palynology in Systematics and Phylogeny. The contribution of **Woodhouse (1935)** through thepublication of the book "Pollen Grains", marked the beginning of purposeful studies on angiosperm pollen. **Eardtman's (1952)** book **"Pollen Morphology and Plant Taxonomy in Angiosperms"** laid a solid foundation of Palynology and demonstrated the importance of pollen morphology in plant taxonomy. **Erdtman, G (1969)** proposed **NPC system of pollen classification** based on **Number, Position and Character** of the pollen apertures.

In India pioneer workers in the field of Palynology are Birbal Sahni, P. K. K. Nair, Vishnu Mittre and S. K. Srivastava. P.K.K. Nair considered as **Father of Indian Palynology.**

The main centres of research in Palynology in India are – National Botanical Garden **(NBG)**, Lucknow; Birbal Sahni Institute of Paleobotany **(BSIP)**, Lucknow and Bose Institute, Kolkata.

Pollen grains are found in every nook and corner, e.g., in glacier ice, in the air over the poles and over the Oceans.

Fossil spores are found in peat and other sediments, in lignite, coal and shales. **They are evident since Pre-Cambrian Times,** hundreds of millions of years ago.

The Exine of Pollen grains are extremely resistant andremain as such for a very long period. Therefore, the data provided by them as fossil has been used successfully in the interpretation of the past vegetation. **Analysis of fossil pollen is the most important approach to the reconstruction of past flora, vegetation and environment.The ability to identify plants on the basis of their pollen morphology has enabled Palaeobotanists and Ecologists to reconstruct past assemblages of plants and identify periods of environmental change.**

Aeropalynologicalstudies (Pollen in the air) of any locality can be used to get a picture of the local flora. Pollen grains are studied after **Acetolysis** (using a mixture of **Acetic anhydride** and concentrated $\mathbf{H_2SO_4}$ in the ratio of **9:1**).Pollen morphology has played an important role in identification and splitting of genera.

Pollen characteristics such as **Shape of pollen, Polarity, Symmetry, Size, Number of apertures, Aggregations and Exine** (sporoderm) have been used in taxonomic botanyfor a very long time.

Modern taxonomy has been shown to benefit much from external and internal characteristics of pollen grains. The taxonomic and evolutionary importance of pollen grains at specific, generic or even higher levels are significant.

The application of scanning electron microscopy **(SEM)** has proved to be a useful tool fpr palynological studies with increased accuracy and precision. This has proved new opportunities for

better understanding of the exine ornamentation patterns. It enabled application of exine features in studies involving systematic relationships of microtaxa, particularly subspecies, varieties, cultivars, cytotypes, bioforms, etc.

The size and shape of pollen, pollen characters such as number and position of furrows, number and position of apertures and details of sculpturing (The external features of the pollen grain wall are termed as Pollen sculpturing) of the exine are of taxonomic value.

The form, number, distribution and position of apertures are important palynological criteria in assessing relationships and phylogeny of plants.

According to the position, the aperture may be proximal, distal, and zonal. In terms of evolution, the proximal position of aperture is most primitive and zonal position of aperture is most advanced.

Pollen polarity is the spatial orientation of the pollen grains leading to the formation two distinct poles.

Morphological Characters used and their Terminology

The various characters used and their terminology are as follows:

1. **Polarity**: It is expressed in terms of their arrangement in the pollen – tetrads. The end directed towards the centre of the tetrad is the **Proximal end** or**Pole**and that towards the outside, is the **Distal pole**. The hypothetical line connecting the two poles is the polar axis and the axis perpendicular to it, is the **Equatorial end**.
2. **Apertures**: Pollen lacking apertures are called **Inaperturate**, while with apertures as Aperturate. Most pollen grains are aperturate. Apertures vary in form, number, position and distribution on exine surface. Apertures when alongated or elliptical are called **Colpate,** when circular, **Porate.** The margins of apertures may be thin **(Tenuimarginate)** or thick **(Crassimarginate).**
3. **Pollen size and Shape:** In consideringthe size, the polar diameter (P) and the equatorial diameter (E) of pollen are taken into consideration, shape is expressed in terms of their respective sizes. Shape classes have been decided, on the basis of the formula **P/E x 100.**

	50 to 75	**Oblate-sphaeroidal**
	76 to 100	**Oblate**
	101 to 113	**Prolate – sphaeroidal**
\	**114 to 133**	**Subprolate**
	134 to 200	**Prolate**
	>200	**Perprolate**

In addition to this, there may be **Bilateral pollen grains** which can be **Planoconvex, Biconvex, Concavoconvex etc.**

POLLEN CHARACTERS CONSIDERED FOR TAXONOMIC ANALYSIS ARE:

1. Pollen unit type, 2. Pollen grain polarity, 3. Pollen grain shape, 4. Pollen grain symmetry, 5. Pollen grain nuclear state, 6. Pollen wall architecture, 7. Exine stratification, 8. Exine structure, 9. Exine sculpture, 10. Aperture type, 11. Aperture number, 12. Aperture position, 13. Aperture shape, and 14. Aperture structure.

Number, Position and Character (NPC) System (Eardtman, 1969)

- NPC refers to Number (N), Position (P) and Character (C) of aperture. In this system, the usage of the term **"treme"** has been recommended in place of aperture. Pollen grains without aperture are called **Atreme**, also represented as No. Depending on the number of aperture, the pollens are named **Monotreme (N_1), Ditreme (N_2), Tritreme (N_3), Tetratreme (N_4), Pentatreme (N_5), or Hexatreme (N_6).** Pollen grains with more than 6 apertures are said to be Polytreme and represented as N_7.
- As far as **Position (P)** of aperture is concerned, there are seven categories **(P_0 to P_6).** When aperture is on the proximal face, pollen is called **Catatreme** and **Anatreme**, if it is on the distal face. It is called **Zonotreme** when apertures are located on equator.
- For **Characters** also, there are **seven groups (C0 to C6).**
  - **C_0** : When aperture is not known;
  - **C_1** : Aperture like thin area of leptoma; when leptoma is on proximal face, they are called Catalept and Analept, if on distal face.
  - **C_2** : Represented by 3-slit Colpus.
  - **C_3, C_4, C_5** and **C_6** refers to **Colpate, Porate, Colporate, and Poroporate** respectively.

❖ STENOPALYNOUS AND EURIPALYNOUS TAXA

(a). **Stenopalynous Taxa**: Taxa where pollen show no variation in shape, size and sculpture, e.g. Poaceae and Brassicaceae.

(b). **Euripalynous Taxa**: Taxa where more than one type of pollen differing in size, shape and sculpture are found, e.g., Asteraceae, Acanthaceae, and Convolvulaceae.

At family level Pollen grain morphology is found valuable in the classification of the family Saxifragaceae. *Berenicearguta* genus was kept in this family because of floral whorl characters. On pollen study, it was found that this taxa is more close to Campanulaceae. So, it was transferred to Campanulaceae.

❖ The family Berberidaceae has been variously circumscribed by different taxonomists. Based on pollen characters, Podophyllum where the pollen grains remain united, has been removed to a

separate family Podophyllaceae. The pollen grains are free in other members of the family Berberidaceae.

- Pollen grain characters, such as shape, size, number of spicules, transverse size, colpus and polar area index, were useful for separating *Verbesina barrance* and *V.crocata*, two morphologically close Mexican species.
- Studies on the palynology of Orchidaceae indicate that the pollen and pollinaria provide useful diagnostic features in supra-generic categories.
- Aperture type (pantoporate, tricolpate, tricolporate) and the exine ornamentation were found to be the most valuable diagnostic characters for distinguishing the genera *Polygonum, Persicaria, Antigonon, Rumex, Fagopyrum* and *Homalocladum*.
- Pollen morphology of the *Rosa* species from Western Himalaya found distinguishable on the basis of exine ornamentation.

- *Salix* and *Populus* (Salicaceae) can be distinguished on the basis of pollen shape and apertures. *Salix* has long and narrowed 3-furrowed pollen as compared to spherical pollen without distinct apertures in *Populus.*

Salix	***Populus***
Pollen long and narrow with 3 furrows	Pollen spherical, without distinct aperture

- The three subfamilies of Apocynaceae can be distinguished from each other on the basis of pollen features:

Apocynoideae	**Asclepiadoideae**	**Periplocoideae**
Single-grained pollen and translators are absent.	Pollens are attached to wishbone-shaped translators consisting of caudicles and corpusculum.	Pollen grains united in tetrads that are carried in spathulate pollen carriers or translators.

- The tribe Bombaceae of the family Malvaceae has been recognised as a separate family Bombacaceae on the basis of pollen characters.

- Species of *Anemone* can be distinguished on the basis of aperture of pollen. It is 3-zonocolpate in *Anemone obtusiloba*, pentaporate in *A. alchemillaefolia* and pentacolpate in *A. rivularis*.

Anemone obtusiloba	***Anemone alchemillaefolia***	***Anemone rivularis***
Pollen 3-zonocolpate	Pollen pentaporate	Pollen pentacolpate

- Variations in the aperture and exine ornamentation may help in the identification of various species of *Bauhinia*.

- The **thickening of exine around the pores** makes a distinguishing character for different genera of the Betulaceae. **In optical section, it is knob-like in *Betula*, club-shaped in *Corylis*, unexpanded in *Caprinus* and an arcus is present between adjacent pores of *Alnus*.**

- The two genera of the Phytolaccaceae, *Phytolacca* and *Rivinia*, can be recognized on the basis of palynological characters. The pollen of *Phytolacca*is 3-zonocolpate, whereas that of *Rivinia* is pentacolpate.

Phytolacca	***Rivinia***
Pollen 3-colpate	Pollen colpate

- Pollen size has been useful in distinguishing two species of *Malva-M. rotundifolia* and *M. sylvestris*.
- Two species of ***Halorgis*** can be differentiated and recognized on the basis of pollen characteristics.

H. ciliata	***H. alata***
Pollen Sub-oblate, Eqatorial diameter – 36 Aperture non-protruding	Pollen Oblate, Eqatorial diameter – 25 Aperture protruding

- IN MAGNOLIIDAE THE POLLEN IS BINUCLEATE.
- IN CARYOPHYLLIDAE THE POLLEN IS TRINUCLEATE.
- IN ERICACEAE THE POLLEN IS IN TETRADS.
- IN ASCLEPIADACEAE POLLEN REMAIN IN POLLINIA.
- IN *TARAXACCUM* THE POLLEN WALL IS ECHINATE.
- IN *QUERCUS* THE POLLEN WALL IS SCABRATE.

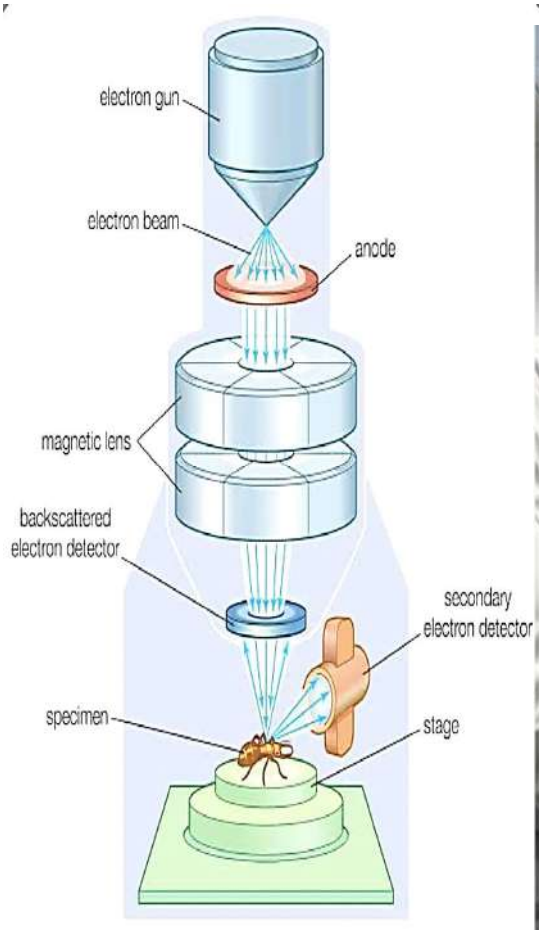
Palynological studies have also contributed in the elucidation of **phylogenetic relationships.** These studies suggest two distinct phylogenetic stocks in the dicotyledons – **monocolpate** and **tricolpate** represented by Magnoliaceae and Ranunculaceae, respectively. The presence of monocolpate element in the monocotyledons indicates that they are more closely related to the Magnolian stock. Furthermore, the monocotyledons and the Magnolia dicots (both have monocolpate elements, characteristic of the preangiospermous arhcaegoniates) are considered more ancient palynologically than the Ranalian dicots where monocolpate elements are completely absent and new apertural forms are present.

Kuprianova (1948), who studied the morphology of pollen in the monocotyledons considered that the Helobiae are not related to the other monocotyledons but are specialized Polycarpieae with Ranalian affinities. She also pointed out that most monocotyledonous families could be considered to have evolved from Arecaceae or Liliaceae.

DICOTS → **Magnoliaceae with Monocolpate Pollen [Monocots closely related]**

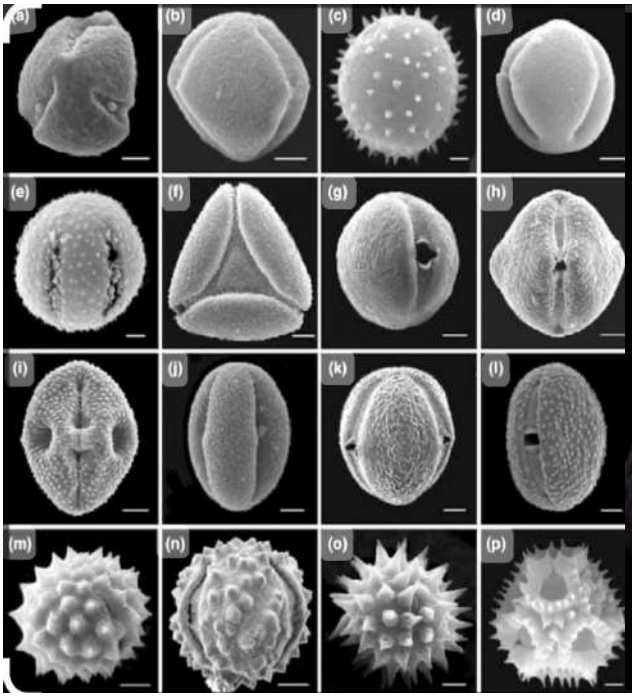
Ranunculaceae with Tricolpate Pollen

- **It is suggested that only palynology can not be taken to ascertain taxonomic positions.**
- **Another limitation is that a particular character can not be universally applied for all taxa.**
- **Similar type of pollen are found in diverse taxa.**

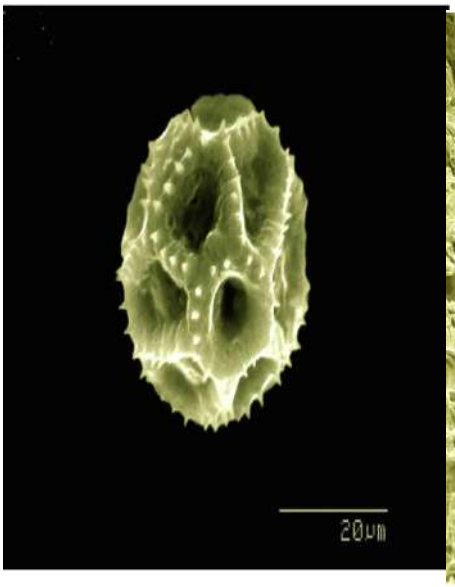


SEM

Pollen observation through SEM



Verbena pollen, SEM



Dandelion pollen imaged in a scanning elec...

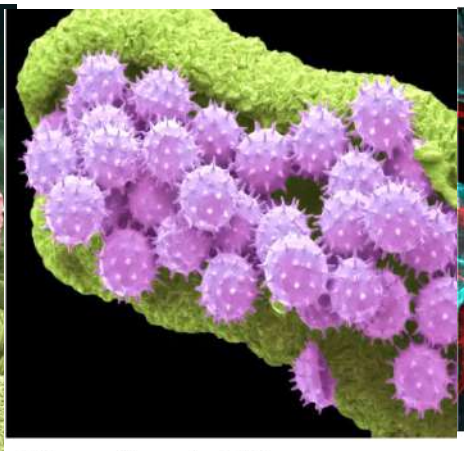
Chinese hibiscus pollen

Convolvulus pollen grains, SEM

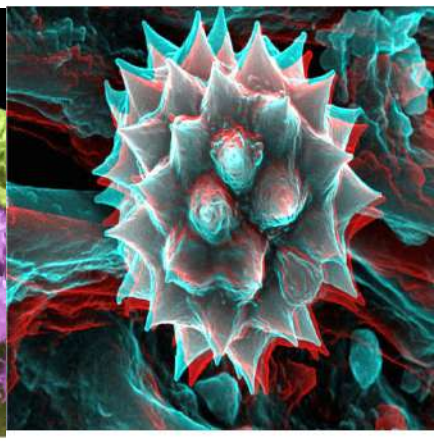
Coloured SEM of Daffodil pollen

Daisy, x1000 magnification

Passion flower pollen

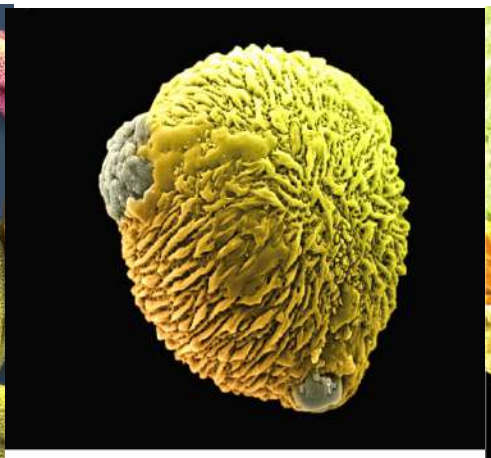


Hibiscus pollen grains, SEM

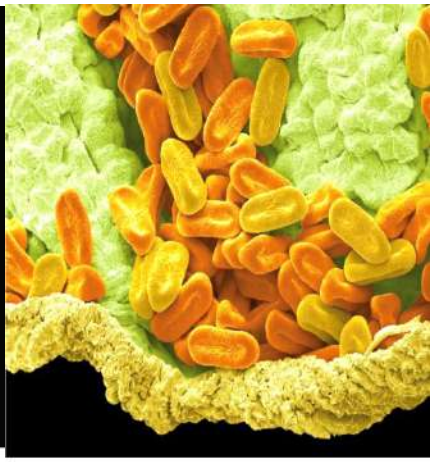


3D SEM image of chamomile pollen, 8 degr...

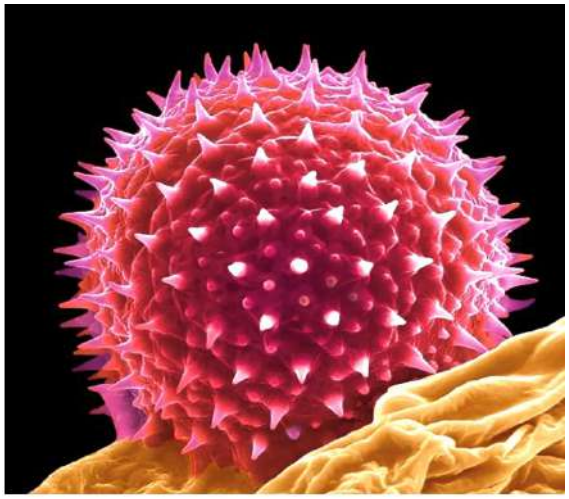
Water lily pollen grains, SEM



Colourised SEM image of Atropa pollen, sh...



Verbena pollen, SEM



Hollyhock pollen grain, SEM

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