

Origin of Angiosperms (T.Y.B.Sc)

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Introduction

- Angiosperms form a distinct group of seed plants sharing a unique combination of characters
- These important characters are carpels enclosed in ovule, pollen grains germinating on stigma, sieve tube with companion cells, double fertilization resulting in triploid endosperm & highly reduced male & female gametophyte.
- Angiosperm also have vessels.
- Angiospermic flower typically hermaphrodite structure with carpel surrounded by stamens & later by petals & sepals since insect pollination prevails. Many plants are unisexual also.
- Arbuscular mycorrhizae are also unique to Angiosperms (Except Amborellaceae, Nymphaeales & Austrobaileyales)
- Angiosperms evolved during cretaceous period 100-125 million years ago
- They developed flowers & fruits to attract pollinators & protect their seeds.
- The fossil record of angiosperm support that, they have appeared suddenly in cretaceous age as full fledged like the trees & the herbs of today
- On the origin of angiosperms some have view that they have monophyletic origin & some have polyphyletic origin
- According to Thomas H.H. (1936) evolutionary tendencies indicate that, they have close relations with characters of Cytoniales, Bennettitales (extinct orders of seed plants) & Pteridosperms, early in mesozoic period.

Due to scattered literature & views about origin of angiosperms, some of popular theories of origin of angiosperms are

- 1. The Isoetes:** Monocotyledon theory of Campbell- origin of angiosperm (Monocots) from Isoetes like plants
- 2. The Proangiosperm Theory:** This theory considered that, a group of plants existed in mesozoic era having bisporangiate flowers with or without a rudimentary perianth & are animophilous called proangiospermae. Engler & Prantls (1924) system of classification is based on this theory. Theory considered that the Pandanales of monocots & Amentiferae (With catkin inflorescence) of Dicot are considered primitive which may be derived from proangiosperms
- 3. The Gymnosperm Theory:** According to this theory Gnatales may be ancestors of Angiosperms
- 4. The Phyllospermae (Plants in which Seed Born on Leaves)/Stachyospermae (Plants in which Seeds Born on Stem) theory-** Angiosperm origin may be from pteridophytes (Sahani) in two separate lines. One from foliar type carpels (Phyllospermae) & other has carpels or megasporangia protected by sterile microsporangiophores
- 5. The Hemiangiosperm Theory:** A group of plants with cycadeoid flowers existed that gave rise to modern flowering plants called hemiangiosperms (A hypothetical group). This theory was proposed by Arber & Perkins (1907) & supported by Bessey, Hutchinson, Hallier.

PSEUDANTHIAL THEORY

- i. This theory was first proposed by **Wettstein** (Austrian Botanist) in 1907.
- ii. He postulated that Angiosperms were derived from the **Gnetopsida** & represented by **Ephedra, Gnetum & Welwitschia** (Formerly all placed in same order)
- iii. The group shows more angiosperm characteristics than any other group of living or fossil gymnosperms. **These include the presence of vessels, reticulate dicot like leaves (Gnetum), male flower with perianth & bracts, strong gametophyte reduction** etc.
- iv. **Ephedra** resemble **Casuarina** in habit. Wettstein (Austrian Botanist) match the **compound strobili of Gnetales** with the **inflorescences of wind pollinated Amentiferae** & regarded the showy insects pollinated bisexual flowers of **Magnolia (Genus of Magnoliaceae)** as **pseudanthia (inflorescence)** derived by aggregation of unisexual units, the carpel thus representing a modified branch
- v. A number of features refute this theory that the different origin of vessels (**Bailey 1944**) in angiosperms (from tracheid's with scalariform pitting) & **Gnetopsida** (from tracheids with circular pitting), several vessel less living angiosperms (Winteraceae)

(In Fagales (Order) ...in an artificial group called Amentiferae. The chief features of the members of Amentiferae were **staminate flowers, and frequently also pistillate flowers, in catkins, reduced or absent sepals and petals, and a general trend toward wind pollination (anemophily)**)

- vi. **Amintiferae** are now regarded as advanced due to **floral reduction**. **Tricolpate pollen grains also** represent an advanced condition.
- vii. But this theory has been strongly supported by **Young (1981)**, who challenged the view that 1st angiosperm were vessel less & assumed that vessels were lost in several early lines. Muhammad & Sattler (1982) found **scalariform perforation** in vessel elements of **Gnetum**, suggesting that angiosperm may be derived from **Gnetales** after all. The basal group of angiosperms according to this theory included **amentiferous hamamelid** orders like **Casuarinales, Fagales, Myricales & Juglandales**. It is significant to note that Wettstein (1907) also included in this basal group, **Chlorathaceae & Piperaceae**, Which have been inviting considerable attention in recent years.
- viii. The importance of **Gnetopsida** in angiosperms phylogeny has been further strengthened by the discovery of **Walwitschia** like fossil describe by Cornet (1996) as **Archaeostrobus cupulanthus** from the Late Triassic of Texas (State in US)
- ix. Ephedra is generally considered to be the most primitive of three living genera of Genetopsida
- x. Cornet believes that Archae strobilus possessed characters that may be plesiomorphic even for ephedra, such as radial symmetry of floral parts which are spirally arranged & not opposite. He believes that **Bennettiales, Gnetales, Pentoxylales & Angiosperms** had a common ascestry sometimes before Late triassic. Gnetales are relatives of angiosperms & Bennettiales that underwent drastic floral reduction & aggregation in response to wind pollination.



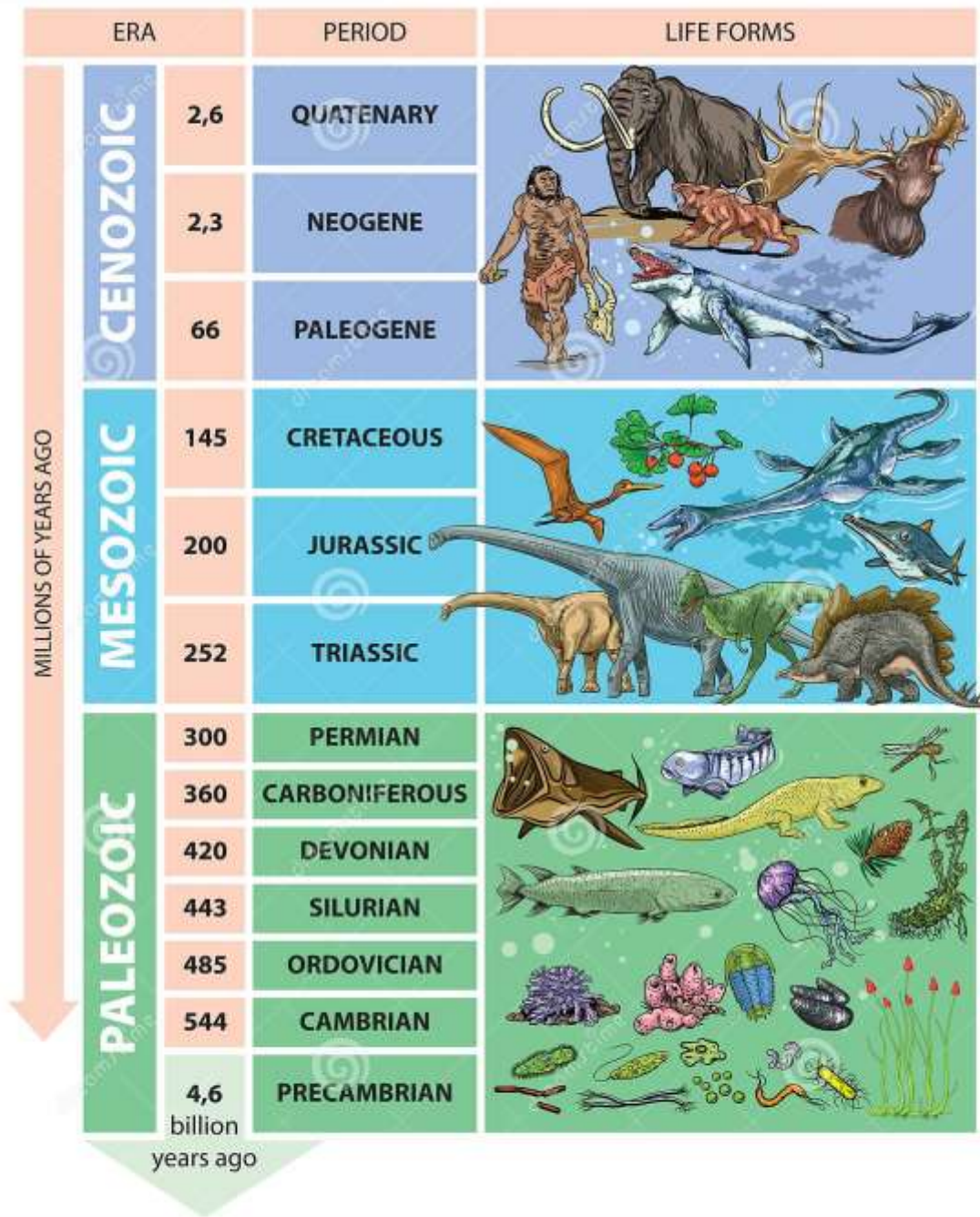
Ephedra



Gnetum



Welwitschia



Transitional & Combinational Theory

1. **J. Stuessy (2004)** published a **Transitional Combinational Theory** for the origin of angiosperms
2. The theory suggest that the angiosperm evolved slowly from the **seed ferns** in the **Jurassic period**
3. **Carpels** was the first to develop, followed by the **double fertilization** & then the development of **flower**. These three fundamental transitions may have taken more than 100 million years to compete.
4. The **extent angiosperms** did not appear until **early cretaceous** when the final combination of all three important angiosperm featured occurred, as presented by fossil record
5. This combination provided the opportunity for explosive **evolutionary diversification**, especially in response to selection from **insect pollinators**, as also the accompanying modifications in **compatibility & breeding systems**
6. The theory attempt to explain discrepancy between **fossil & molecular phylogenetic data**, latter suggesting pre-cretaceous origin of angiosperms when DNA (AND PROTEIN) sequences showed first changes accompanying carpel evolution, much earlier than final combination of all the three angiosperm features.
7. This theory also suggests that barring extinct seed ferns, from which the carpel arose, other gymnosperms had no direct phylogenetic connections to modern angiosperms
8. Stuessy (2004) suggest that meaningful morphological cladistics analyses should focus on ties between **pteridosperms & angiosperms directly**, and not include rest of the gymnosperms. He developed angiosperms pollen, took place only after the flower had developed, explaining the absence of angiosperms pollen record prior to 130 MYA

Chapter 02

Speciation & Endemism

- **Introduction:** The species is the most basic category in the system of Taxonomy
- According to the biological species concept, organisms belongs to the same species if they can interbreed to produce viable, fertile offspring
- Species are separated from one another by pre zygotic & post zygotic barriers, which prevent mating or production of viable, fertile offspring.
- Speciation is the process by which new species is form

- **Species: Concept**
- **Zoologist Mayr (1942)** who defined species as group of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups
- Species is a unit of **taxonomic convenience** & that the population
- **Definition:** The ability of two individuals to successively produce viable, fertile offspring's (**Biological Species Concept**)
- According to **Dobzhansky (1937)** the species are the mendelian populations which share common gene pool.
- Mendelian population is defined as a community of similar individuals living within a particular area & particular time & capable of interbreeding
- According to **Emerson** a species is a **genetically distinctive** & **reproductively isolated** natural populations
- **Merrel** defined species as natural biological unit tied together by bonds of mating & sharing a common gene pool

- Whether individuals look similar (**morphological species concept**), how closely related individuals are evolutionary (**phylogenetic species concept**), and whether the individuals use or can use the same set of biological resources, in other words, whether they occupy the same niche (**Ecological species concept**).
- Which species concept is most useful depends on circumstance & available data

- **Speciation:** It is defined as the formation of new species as a result of **geographical, physiological, anatomical or behavioural** factors that prevent previously interbreeding populations from breeding with each other
- It is the process that results in **new species**, occurs when an ancestral population splits into two or more descendant species which are genetically distinct & unable to interbreed (as per biological species concept)
- Speciation is all about gene flow, the less gene flow, the more likely speciation is to occur.

Speciation is all about gene flow or lack thereof. The less gene flow, the more likely speciation is to occur.

Allopatric Speciation:

1. It occurs when two populations are physically isolated from each other (allopatry), creating the absence of gene flow. Geographic isolation occurs when a beetle population is divided by a body of water that prevents interbreeding between the two populations.
2. Small changes occur in each isolated population over time, and if changes occur that prevent successful production of fertile offspring, then when the isolating barrier is removed, the two populations can no longer interbreed

e.g. The classic example is **Darwin finches**. The divergent population (when two populations separated by geographical barrier) of finches inhabiting the Galapagos islands were observed to have differences in features such as body size, colour, and beak length, or shape. The differences resulted because of the different type of the food available in various islands

Sympatric Speciation:

1. It occurs when two populations in the same location become unable to interbreed due to **reproductive isolation**, which reduces gene flow between populations & thus increases the likelihood of speciation occurring. Reproductive isolation mechanism can be **pre zygotic & post zygotic**, which is way to say before or after sperms & eggs unite to form a zygote

Pre zygotic reproductive isolation:

- i. Behavioural difference in mating song or dance, meaning individuals don't even recognize each other as possible mates
- ii. Sperm egg incompatibility, meaning that individuals might attempts to mate, but it is not possible for the sperms to fertilize the egg

Post zygotic reproductive isolation:

- i. Developmental failures and spontaneous abortion, meaning that the embryo does not develops properly & is therefore inviable (not capable of living)
- ii. Growth & development of a viable (living) fully formed adult offspring's that are themselves **sterile** (infertile), meaning that the offspring's are not capable of reproducing

e.g. Sympatric speciation is observed in apple maggot flies which 200 years ago laid eggs & bred only on hawthorns (Thorny shrub or tree) but now lays eggs on both hawthorns and domestic apples. As a result, gene flow between parts of the population that mate on different types of fruits is reduced, and in fewer than 200 years, some genetic differences between these two groups of flies have evolved.

Parapatric Speciation:

- i. Parapatric speciation is a mode of speciation in which there is no extrinsic barrier between the population but, the large geographical range of population causes the individuals to mate with the neighbouring individuals than with the individuals in a different parts of the geographic range. In this case population is continuous, but the population does not mate randomly. Here the genetic variation occurs as a result of reduced gene flow within the population & varying selection pressure across the population's range.

This occurs in a population which is distributed over a large geographical range. Thus, the individuals in the far west region cannot mate with the individuals in the far east region.

Eg. The grass species *Anthoxanthum odoratum* where some species living near the mine have become tolerant to heavy metals. However, other plants that don't live around the mines are not tolerant.

Epibiotic or Relic, endemics: The plants belong to Fossil groups and are restricted to few pockets due to favourable climate lack of competition Eg. *Ginkgo biloba* which is restricted to China but widely spread in North temperate zone as a fossil