Paleobotany

- The study of the plant life of the geological past is called **Paleobotany.**
- The earliest plant fossils, bacteria and blu-green alge occurring in the earliest **Pre-Cambrian rocks of 3.1 my**.
- The earliest plants were aquatic
- During the evolution, the aquatic plants migrated towards the land.
- As the condition of the land are quite different from that in water, various morphological and anatomy of plants took place.
- The major changes includes 1. development of cuticles or epidermis, 2. Vascular tissue system, 3. Root and shoot system and 4. Productive covering around reproductive bodies.

- Plants are classified into **Non-vascular and vascular** plants

Non-Vascular Plants

- The simplest plants, the algae, bacteria and fungi are often grouped together under Thallophyta (non vascular plants).
- They consists of soft tissues showing no differentiation into roots, stems and leaves.
- Terrestrial thallophytes are rarely fossilized and thus little information available.

Vascular Plants

- The vascular plants possess a highly organised food and water conducting structure called "Stele"
- The vascular plants are classified on the basis of nature and relationship of leaf and stem, vascular anatomy and position of sporangia in to four divisions such as **Psilopsida, Lycopsida, Sphenopsida and Pteropsida.**

Psilopsida

- Age is Upper Silurian to Upper Devonian
- It is known as seedless plants with simple organization

Lycopsida

- Lycopsida are plants of modest and dimension with simple. Small spirally arranged leaves.
- It provided with vascular system
- This plant was dominant during carbonaceous period which includes forest tree and woody plants.

Sphenopsida

- Plants of this division are also called Articulatales Arthophyta.
- They include bushes and relatives
- Their leaves are attached by a narrow base.

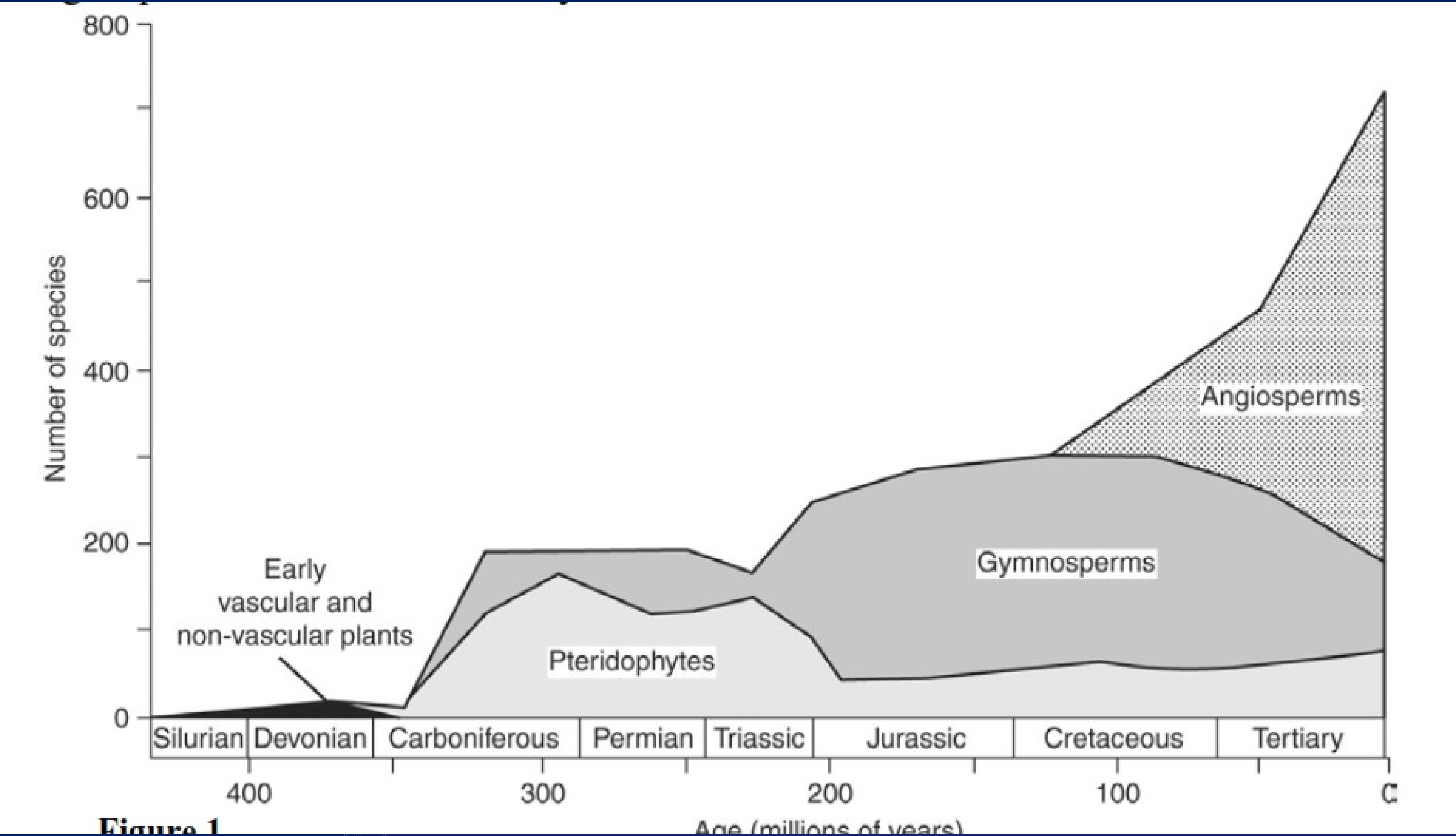
Teropsida

- This division includes ferns, seed-ferns Gymnosperm and Anngiosperm
- It was further divided in to three classes such as Filincineae, Gymnospermae and Angiospermae.

THE OBJECTIVES OF PALEOBOTANY

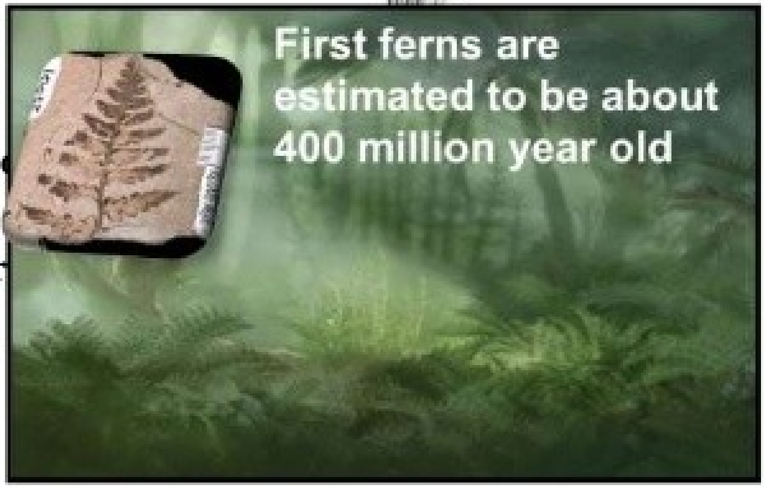
- One of the aspects of paleobotany, it can be approached from inherently interdisciplinary either a biological or a more geological perspective—or both together.

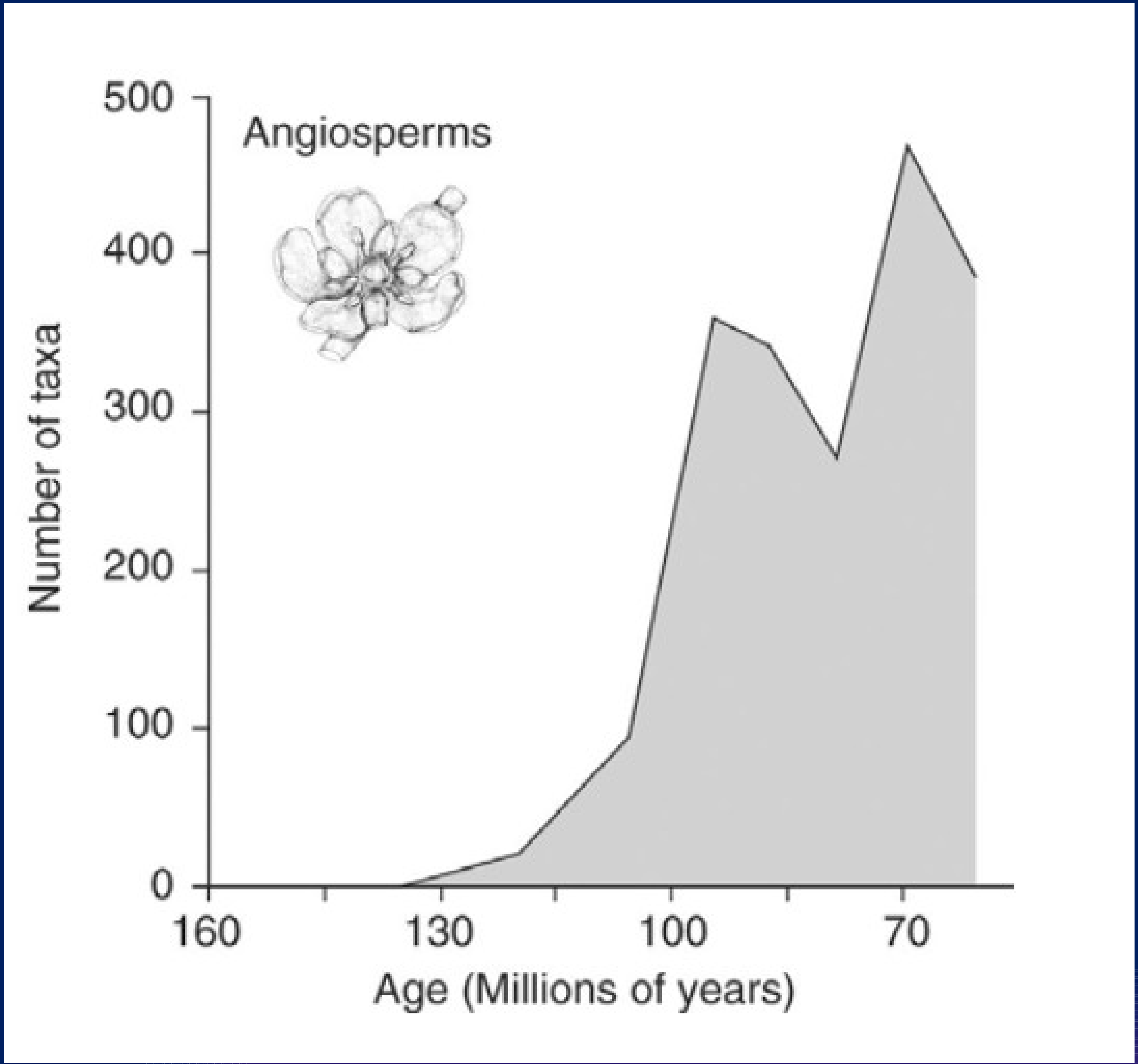
- Each perspective presents a variety of questions that are unique to that discipline.


800
600
400
200
0
Number of species
Early vascular and non-vascular plants
Pteridophytes
Gymnosperms
Angiosperms
Silurian
Devonian
Carboniferous
Permian
Triassic
Jurassic
Cretaceous
Tertiary
400
300
200
100
Figure 1
Age (millions of years)

Pteridophytes

- **Seedless** vascular plants – **Vascular cryptogams**
- In **Gk Pteron** means. **Feather** , **phyton** means plants (Feather like fronds / leaves)
- Reproduce by means of **spores**
- **First land plants**



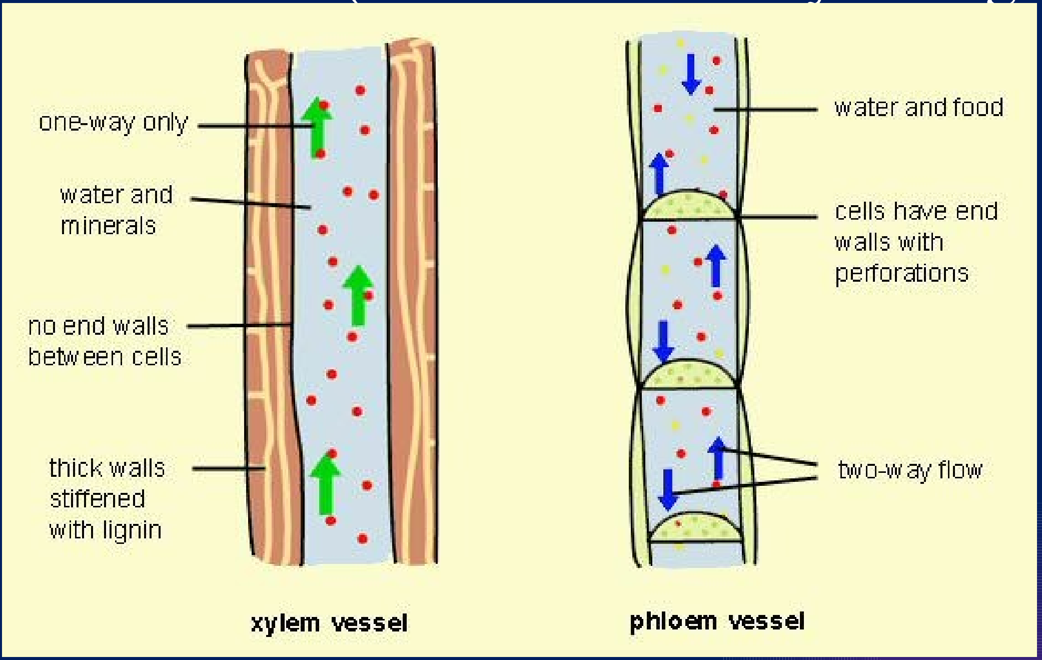

Angiosperms
Number of taxa
500
400
300
200
100
0
160
130
100
70
Age (Millions of years)

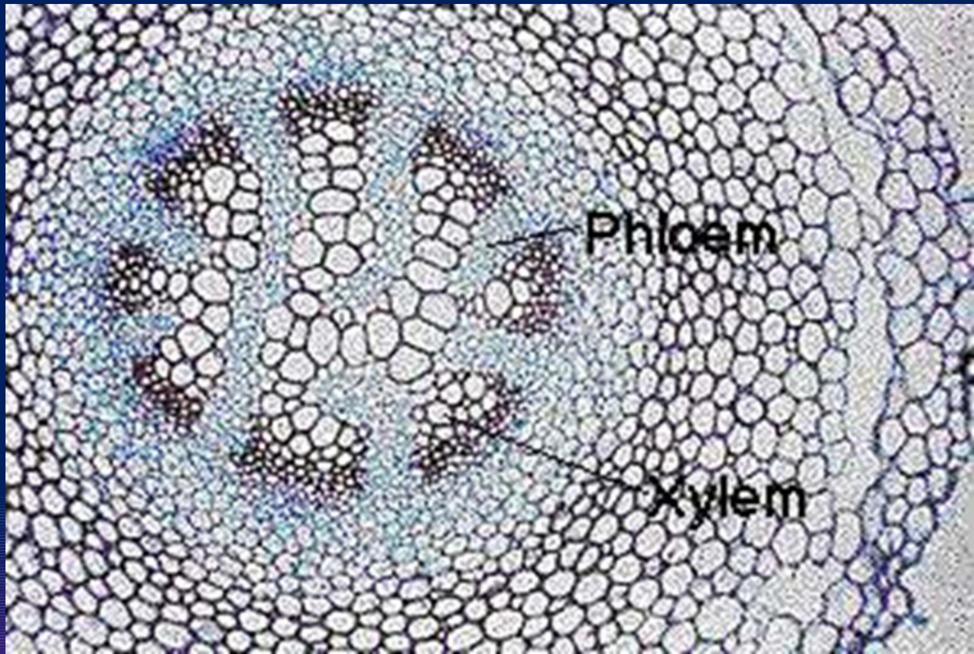
- In the Mesozoic Era the terrestrial vegetation evolved greatly.
- At the beginning of the Era, plants from the Carboniferous Period were very common, especially ferns, seed ferns, lycopsides and horsetails.
- The gymnosperms appeared also in Carboniferous Period but did not become dominant until Triassic.
- In the last part of Triassic and Jurassic, gymnosperms (non-flowering plants) increased in diversity and many new species were formed.
- The most dominating plants of terrestrial vegetation evolved greatly. Ex. ginkgo, cycads, bennettitales and conifers.

- In the Cretaceous the angiosperms (flowering plants) began to appear and they increased their diversity and quantity in a very short time.
- These coloured flowers and fruit bearing trees dramatically changed the appearance of the forests. At the end of the Era, flowers and large trees were spread all over the earth and provided a most encouraging environment for both insects and animals.
- The biomes were diverse and grew well. Under these circumstances, dinosaurs, birds, insects and small mammals flourished in the forests.

- Plants are classified into two main groups: **the bryophytes** (nonvascular plants) and the **tracheophytes** (vascular plants).
- Both groups have multicellular embryos, which indicates that they are closely related to each other and distinguishes them from the green algae.
- Indeed, true plants are often referred to as embryophytes because of this feature. The bryophytes consist of the liverworts, hornworts, and mosses, and as their name implies none of these plants possess vascular tissues.

- All other plants, including the ferns, gymnosperms, and angiosperms, are classified as **tracheophytes.**
- These possess specialized vascular tissues— **phloem** and **xylem** —to transport sugars, water, and **minerals** throughout their bodies.
- The oldest known vascular plants appeared in the middle Silurian period (439–409 million years ago);





- The oldest known bryophytes appeared later, in the Devonian (409–354 million years ago).
- Most scientists believe that bryophytes evolved before vascular plants, and that the earliest bryophytes have not been found because they fossilize poorly.
- This belief is supported by a variety of evidence, including morphological traits, ultrastructural features visible under the electron microscope, and molecular information obtained from **gene** sequencing.

- The first detailed vascular plant fossils appear in rocks from middle Silurian, about 425 million years ago.
- The oldest of these, including a plant called *Aglaophyton,* appear to have possessed conducting cells similar to the hydroids of mosses.
- These ancient plants, which are sometimes called prototracheophytes, may have been an evolutionary link between the bryophytes and the true tracheophytes.
- Early vascular plants possessed two features that made them especially well adapted to life on land.

- First, their vascular tissues transported sugars, nutrients, and water far more efficiently than the conducting cells of mosses.
- Second, they evolved the ability to synthesize **lignin** , which made the cell walls of their vascular tissues rigid and supportive.
- Taken together, these features allowed them to grow much larger than their bryophyte ancestors and considerably reduced their dependence on moist habitats.

Gymnosperms:

- The gymnosperms probably evolved from an extinct phylum of seedless vascular plants, the progymnosperms, that appeared about 380 million years ago.
- The fossils of these plants, some of which were large trees, appear to form a link between the trimerophytes (another extinct phylum of seedless vascular plants) and true gymnosperms.
- Progymnosperms reproduced by means of spores, but their vascular tissues were very similar to those of living conifers.

- The oldest true gymnosperms, which produce seeds rather than spores, first appeared about 365 million years ago.
- The evolution of seeds, with their hard, resilient coats, was almost certainly a key factor in the success of the group. A second factor was the evolution of pollen grains to protect and transport the male gametes.
- As a consequence of this, gymnosperms, unlike seedless vascular plants, were no longer dependent on water for successful **fertilization** and could broadcast their male gametes on the wind.

- Several early gymnosperm groups are now extinct, but there are four phyla with living representatives: the cycads, the gnetophytes, the conifers, and one phylum (Ginkgophyta) that has only a single living species, the ginkgo tree (*Ginkgo biloba*).
- Of these, the conifers are by far the most abundant and diverse, and many species are of considerable ecological and economic importance.
- Most conifers are well adapted to dry environments, particularly in their leaf **morphology** , and some can withstand severe cold.
- These features may have enabled them to thrive in the Permian, when Earth became much drier and colder than it had been in the Carboniferous.

Angiosperms

- The angiosperms, or flowering plants, are all members of the phylum Anthophyta.
- There are at least 250,000 species, making the group easily the most diverse of all plant phyla.
- They share a number of features that distinguish them from other plant groups.
- The most obvious of these is the possession of flowers, highly modified shoots that carry the male and female reproductive structures.
- They also carry out a process called double fertilization, in which two male gametes (sperm nuclei) are released from the pollen tube into the **ovule** . One of these sperm nuclei fuses with an egg cell in a similar way to gymnosperms.

- The second nucleus (which degenerates in most gymnosperms) fertilizes other cells in the ovule called polar nuclei. Most commonly, two polar nuclei fuse with the sperm nucleus to form a **triploid endosperm** nucleus. The tissue that forms from this fusion is called endosperm, which in most angiosperms provides nutrients for the developing embryo.
- A third feature that separates angiosperms from gymnosperms is that angiosperm embryos are protected by an ovary wall, which develops into a fruit after fertilization has taken place. In contrast, gymnosperm embryos are held relatively unprotected on the surfaces of ovule-bearing scales in the female cones.

Angiosperm Evolution

- Angiosperms first appear in the fossil record about 130 m.y ago, and by 90 million years ago they had become the predominant group of plants on the planet.
- English naturalist Charles Darwin considered the sudden appearance of angiosperms to be an "abominable mystery," and scientists have debated about the origin of the group for many years.
- Comparative studies of living species suggest that angiosperms evolved from the gnetophytes, a group of gymnosperms with three living genera of rather strange plants: *Ephedra, Gnetum,* and *Welwitschia.*
- Double fertilization has been shown to occur in both *Ephedra* and *Gnetum,* and the reproductive structures (strobili) of all three genera are similar to the flowering stalks of some angiosperms.

- Some gene sequencing studies also indicate that gnetophytes and angiosperms are closely related to each other and to an extinct group of gymnosperms called the Bennettitales. However, more recent molecular studies suggest that gnetophytes are more closely related to conifers than they are to angiosperms.
- In 1998, the discovery of an angiosperm-like fossil called *Archaefructus,* which apparently existed 145 million years ago, also cast some doubt on the idea that angiosperms descended from gnetophytes or Bennettitales. Although a great deal of information has been obtained since the time of Darwin, the origin of angiosperms is still something of a mystery.

Early Angiosperms, Monocots, and Eudicots

- The oldest known angiosperms were a diverse group of plants called magnoliids.
- Some of these were herbs with simple flowers; others were woody plants with more complex flowers that were very similar to living magnolias.
- Magnoliids, probably those with small, inconspicuous flowers, gave rise to the two main groups of angiosperms, monocots and eudicots, although a few angiosperm families, including the water lilies, may have evolved earlier.
- These plants possessed a number of adaptations that were probably crucial to their eventual success.

Early Angiosperms, Monocots, and Eudicots

- Their vascular tissues were particularly efficient, their embryos were enclosed in a protective seed coat, their leaves were resistant to desiccation , and they were pollinated by insects, rather than by the wind.
- This last feature made pollen transfer much more efficient and was almost certainly a key innovation in the diversification of the group, as coevolution of plants and their pollinators, particularly bees, gave rise to increasing specialization of both flowers and insects.

Early Angiosperms, Monocots, and Eudicots

- The orchid family contains some of the most specialized insect-pollinated flowers of all and has more species (at least 24,000) than any other plant family.
- Other groups of angiosperms re-evolved the ability to be pollinated by wind. One of these groups—the grasses—appeared about 50 million years ago, diversified rapidly, and became the dominant plants over many regions of the planet.
- They still thrive and are crucial to human well-being. Approximately 54 percent of the food eaten by people is provided by grain (seed) from cultivated varieties of just three grasses: rice, wheat, and corn.

Preservation of Plants Remains

- Dead plants decay at normal conditions
- Plants may be well preserved where the circumstance is exclude the oxygen and aerobic bacteria.
- Three conditions are required for the preservation of plant fossils
  - Removing the materials from oxygen rich environment of aerobic decay.
  - Fixing the organic material to delay anaerobic decay
  - Introducing the fossil to the sedimentary rock reload

Plant fossils are classified into six broad categories

Compression

- 3D Plants are compressed to more or less 2D part.
- It retains organic matter usually more or less coalified.
- Example; Peat, Lignite, Bituminous and Anthracite

Impressions

- 2D imprints of Plants or their parts found most commonly in fine grained sediments such as silty or clay.
- Leaves are most common organs are preserved in impressions
- External shape and morphology is preserved

Plant fossils are classified into six broad categories

Cast and Molds

Cast

- When sediments is deposited into cavities left by the decay of plant fossils.

Molds

- A cavity left in the sediments by the decayed plant tissues
- Molds are generally unfilled or partially filled.
- Lack of organic matter

Plant fossils are classified into six broad categories

Permineralisation

- It occurs when the plant tissues are infiltrated with mineral rich fluids.
- Minerals commonly silica, carbonates phosphates or pyrites.
- Thus, it preserved internal structure of the plants in 3D
- This is also known as structural preservation.
- When the mineral matter replaces the cell-wall and other internal structures, it is called **Petrification.**
- Permineralization by calcite and dolomite common in carboniferous coal seems
- Permineralization by pyrite noticed in Devonian rocks. It is formed in the sea water condition where the **source sulphur** is available

Plant fossils are classified into six broad categories

Compaction

- Found in recent fossils
- Pores and pollens are preserved in this method.
- It shows unidirectional compression (Flattering)
- In Peat, brown coals and soft sediments, plant remains may retain their external form only with slight volume reduction.
- Tissues are not mineralized
- Retain resistant organic materials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