



STUDY MATERIAL

**VIVEKANANDA COLLEGE  
THAKURPUKUR**

NAAC Accredited Grade—A

# **BOTANY**

(HONOURS)

## **Plant Life through the Ages**

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## Plant Life through the Ages

The Earth is approximately 4,700 million years old<sup>1</sup>. Fossils<sup>2</sup> present in the innumerable strata of sedimentary rocks<sup>3</sup> in the Earth's crust are evidences of life from the geological past. Like the pages of a giant book, these rock layers and their plant fossil hold the key to the plant life through the geological ages, including the dominant plant groups and their important evolutionary events as summarized in the table below (Table 1).

**Table 1:** The Geological Time Scale and Major Plant Groups

Eon	Era	Period	Major Plant Groups	Ma
Phanerozoic	Cenozoic	Quaternary	Modern floras.	0
		Tertiary	Modern vegetation types.	2.5
	Mesozoic	Cretaceous	First angiosperms (monocots and dicots).	65
		Jurassic	Cycads, cycadeoids, caytonioids, pentoxylates, ginkgoes and modern conifers.	140
		Triassic	Seed ferns, caytonioids, cycads, ginkgoes, transitional conifers, and herbaceous lycopsids, sphenopsids and ferns.	195
	Palaeozoic	Permian	Seed ferns, glossopterids, transitional conifers, and early cycads and ginkgoes.	225
		Carboniferous	Arborescent lycopsids, sphenopsids and ferns, progymnosperms, seed ferns and primitive conifers, and first higher fungi and mosses.	280
			Devonian	Diversification of vascular plants: rhyniophytes, zosterophyllophytes, trimerophytophytes, early lycopsids, sphenopsids and ferns, progymnosperms and seed ferns; and first bryophytes (liverworts).
		Silurian	First land vascular plants.	395
		Ordovician	Blue-green, green and red algae, and lower fungi.	435
		Cambrian	Diversification of algae.	500
	Cryptozoic	Proterozoic	Pre-Cambrian	First eukaryotes.
Archaean		Bacteria and blue-green algae.		4000
Azoic		No life.		4700

Mega-annum (Ma) or million ( $10^6$ ) years before present (b.p.).  
(Modified from Stewart and Rothwell, 1993).

<sup>1</sup> Based on the radiometric dating of rocks.

<sup>2</sup> From the Latin verb *fodere* (to dig).

<sup>3</sup> A principal rock type formed by the deposition and compaction of sediments in successive strata.

Life on the Earth is thought to have originated in the primordial oceans about 4,000 Ma<sup>4</sup> ago through the events of the chemical evolution of complex organic molecules from simple inorganic ones under the prebiotic conditions (including a reducing atmosphere) existing on the early Earth<sup>5</sup>. Thus, there are no fossils present in oldest-known rocks of the Earth that belong to the Azoic (or Hadean<sup>6</sup>) era (4,000—4,700 Ma b.p.) when these events may have occurred. The oldest-known fossils appear in the geological record during the Archaeozoic (or Archaean) era (2,500—4,000 Ma b.p.). These are relatively rare and represent the earliest life forms, i.e. the primitive bacteria and blue-green algae (prokaryotes). Probably, metabolic evolution among these early life forms subsequently resulted in the appearance of oxygenic photosynthesis, formation of the present oxidizing atmosphere (and the ozone layer) and the beginning of oxidative metabolism. The fossils of the first eukaryotic cells (green algae and probably lower fungi) ultimately appeared in the Proterozoic era (570—2,500 Ma b.p.). Therefore, the rocks of the Cryptozoic (or the Pre-Cambrian) eon, representing most of the immense timespan of the Earth's history, harbour only limited traces of prehistoric life. However, fossils are abundantly present in the rocks of the Phanerozoic eon which only represents the last 570 Ma of the Earth's geological past but during which most of the key events of biological evolution are thought to have occurred resulting in the modern plant forms and vegetation types as we see today.

### The Precambrian Flora

The Pre-Cambrian (or Cryptozoic) eon (570—4,700 Ma b.p.) is often called "**the age of algae**," algae although of doubtful credentials as the primeval seas were dominated by bacteria and blue-green algae (prokaryotes). One of the principal sources of evidence of the putative Pre-Cambrian biota and its antiquity are the **fossil stromatolites**—sedimentary rocks formed by extensive mats of blue-green algae thriving in shallow waters. Although the Archaeozoic ones are barren, the Proterozoic ones harbour microfossils, e.g. *Cryptozoön*. Fossils are completely absent in the rocks of the early Pre-Cambrian, i.e. the Azoic era (4,000—4,700 Ma b.p.). The oldest-known fossils on the Earth are at least 3,500 Ma old and occur in rocks of the Archaeozoic eon (2,500—4,000 Ma b.p.). This Archaeozoic flora was represented by the marine **bacteria** and **blue-green algae** only. The **Fig Tree Formation** (South Africa) which is 3,300—3,400 Ma old has fossils of primitive microbes such as *Eobacterium*, a rod-shaped bacterium, and *Archaeosphaeroides*, a coccoid blue-green alga (Cyanophyta). The earliest-known fossils of **eukaryotic cells (green algae and probably lower fungi)** also appear in rocks of the late Pre-Cambrian, i.e. the Proterozoic era (570—2,500 Ma b.p.). However, the Proterozoic flora continued to be dominated by the marine bacteria and blue-green algae. The **Gunflint Formation** (Canada) which is 1,700—2,500 Ma old has fossils of prokaryotes such as *Gunflintia*, a filamentous bacterium, and *Animikiea*, a filamentous blue-green alga. The **Bitter Springs Formation** (Australia) which is nearly 900 Ma old has various fossils of prokaryotes such as *Palaeolyngbya*, a filamentous blue-green alga, *Eozygion*, a coccoid blue-green alga, as well as a few fossils of the earliest eukaryotes such as *Eomycetopsis*, probably a lower fungus (Oomycota) and *Eotetrahedron*, a green alga (Chlorophyta).

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<sup>4</sup> Mega-annum (Ma) or million (10<sup>6</sup>) years before present (b.p.).

<sup>5</sup> The Oparin-Haldane Hypothesis of the 1920s.

<sup>6</sup> Named after Hades, the Greek god of the underworld.

## The Palaeozoic Flora

The Palaeozoic era (225—570 Ma b.p.) is biologically important due to the evolution of the **marine ancestors** of land plants, their **invasion of land**, and the diversification of **land plants** that included the evolution of **heterospory** and the origin of **seed habit** which produced all major plant groups except the angiosperms. The Cambrian period witnessed the diversification of eukaryotic algae in the ancient seas and the first appearance of their complex multicellular forms. The fossil record includes **bacteria**, **blue-green algae** (Cyanophyta), **green algae** (Chlorophyta) such as *Helimeda* and *Palaeoporella*, **red algae** (Rhodophyta) such as *Solenopora* and *Epiphyton*, and some **lower fungi** (Oomycota). The flora of the Ordovician period was mostly similar. During the Silurian period the colonization of land occurred. The oldest-known land vascular plant fossil, a rhyniophyte<sup>7</sup>, is *Cooksonia*. The diversification of land plants and the emergence of nearly all the major plant groups occurred in the Devonian period. The oldest-known bryophyte fossil, a **hepatic**, is *Pallavicinites*. Fossils of pteridophytes are represented by the **rhyniophytes** (e.g. *Rhynia* and *Horneophyton*), **zosterophyllophytes**<sup>8</sup> (such as *Zosterophyllum* and *Asteroxylon*) and **trimerophytophytes**<sup>9</sup> (e.g. *Trimerophyton* and *Psilophyton*), and the early members of the **lycopsids**<sup>10</sup> (e.g. *Baragwanathia* and *Protolepidodendron*), **sphenopsids**<sup>11</sup> (e.g. *Protohyenia* and *Hyenia*) and **putative ferns**<sup>12</sup> (e.g. *Cladoxylon* and *Pseudosporochnus*). Fossils of gymnosperms are represented by the **progymnosperms**<sup>13</sup> (e.g. *Aneurophyton* and *Archaeopteris*) and some early **seed ferns**<sup>14</sup>. The Carboniferous period is called "**the age of coal**" due to its coal measures, or "**the age of fern**" on account of the frequent presence of fern-like frond fossils (although often belonging to fossil gymnosperms). Fossils of **higher fungi** include *Mycocarpon* and *Palaeosclerotium* (Ascomycota and Basidiomycota). The oldest-known **moss** fossil is *Muscites*. This **coal floras** of this period were dominated by trees that had formed the **coal forests**. Fossils of pteridophytes include the arborescent lycopsids (e.g. *Lepidodendron* and *Sigillaria*), sphenopsids (e.g. *Sphenophyllum* and *Calamites*) and ferns (e.g. *Botryopteris*). Fossils of gymnosperms include the progymnosperms (e.g. *Protoipityx*), seed ferns (e.g. *Lyginopteris* and *Medullosa*) and **primitive conifers**<sup>15</sup> (e.g. *Cordaites*). The coal flora lingered on during the Permian period. Along with the extinction of the seed ferns and arborescent pteridophytes there was the emergence of new gymnosperms in the **southern supercontinent**, viz. fossils of the dominant and enigmatic **glossopterids**<sup>16</sup> (e.g. *Glossopteris* and *Gangamopteris*), along with early **cycads**<sup>17</sup> (e.g. *Archaeocycas*) and **ginkgoes**<sup>18</sup> (e.g. *Trichopitys*), and **transitional conifers**<sup>19</sup> (e.g. *Ullmania* and *Buriadia*).

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<sup>7</sup> Rhyniophyta.

<sup>8</sup> Zosterophyllophyta.

<sup>9</sup> Trimerophytophyta.

<sup>10</sup> Lycophyta.

<sup>11</sup> Sphenophyta.

<sup>12</sup> Pterophyta.

<sup>13</sup> Progymnospermophyta.

<sup>14</sup> Cycadofilicales (= Pteridospermales).

<sup>15</sup> Cordaitales.

<sup>16</sup> Glossopteridales.

<sup>17</sup> Cycadales.

<sup>18</sup> Ginkgoales.

<sup>19</sup> Voltziales.

## The Mesozoic Flora

The Mesozoic era (65—225 Ma b.p.) is also biologically significant due to the emergence of the **modern forms** of pteridophytes and gymnosperms, as well as on account of the **origin of angiosperms** as a result of the evolution of the **carpel**. No coal deposits are present. The Triassic period witnessed the rapid decline and extinction of the enigmatic **glossopterids**. These were soon replaced new gymnosperms represented by the fossils of the early members of another enigmatic group of gymnosperms, the **caytonioids**<sup>20</sup> (e.g. *Dicroidium*, *Umkomasia* and *Lepidopteris*). Other fossils of gymnosperms included the **cycads** (e.g. *Bjuvia* and *Palaeocycas*), **ginkgoes** (e.g. *Ginkgoites*) and **transitional conifers** (e.g. *Voltziopsis*). Emergence of fossil herbaceous pteridophytes that descended from their arborescent ancestors included the fossils of **lycopsids** (e.g. *Pleuromeia* and *Selaginellites*), **sphenopsids** (e.g. *Schizoneura* and *Equisettites*) and **ferns** (e.g. *Danaeopsis*). An outstanding fossil bryophyte is *Naiadita*, which represents an enigmatic **foliose hepatic**. The Jurassic period is called "**the age of cycads and cycadeoids**" due to the abundance of fossil gymnosperm especially the dominant cycad-like **cycadeoids**<sup>21</sup> (e.g. *Williamsonia*, *Williamsoniella*, *Wielandiella* and *Cycadeoidea*). Other fossils of gymnosperms include the **pentoxylates**<sup>22</sup> (e.g. *Pentoxylon* and *Rhexoxylon*), **modern conifers**<sup>23</sup> (e.g. *Araucarites* and *Palaeotaxus*), as well as **cycads** (*Baenia*), **ginkgoes** (e.g. *Baiera*), **caytonioids** (e.g. *Caytonia*), and yet another enigmatic group of gymnosperms, the **Czekanowskiales** (e.g. *Czekanowskia*). Herbaceous pteridophytes gradual decline as well. The Cretaceous period is characterized by the appearance and early diversification of the **angiosperms**—both the **dicots**<sup>24</sup> and **monocots**<sup>25</sup>. The oldest-known angiosperm fossil, from the Barremian-Aptian stage boundary, is *Dictyophyllum*. Some of the most prominent angiosperm fossils from this period include *Archeanthus* and *Lesqueria*. This period also witnessed the appearance of gnetophytes<sup>26</sup> that are represented by the fossils of their earliest members (e.g. *Drewria*). The caytonioids, cycadeoids, pentoxylates and the members of Czekanowskiales declined and finally became extinct. Finally, the cycads and ginkgoes also gradually declined.

## The Cenozoic Flora

The Cenozoic era (0—65 Ma b.p.) in which we live has witnessed the further diversification, radiation and modernization of the angiosperms. Most angiosperm fossils from this era, e.g. *Princetonia* (dicot) and *Heleophyton* (monocot), are comparable with the extant taxa. The ultimate dominance of the angiosperms was accompanied by the eventual decline of the conifers (except in the Tundra and Alpine biomes). The **modern vegetation types** emerged during the Tertiary period. Coal deposits are also known from this age. The **modern floras** finally appeared during the Quaternary period.

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<sup>20</sup> Caytoniales.

<sup>21</sup> Cycadeoidales (= Bennettitales).

<sup>22</sup> Pentoxylales.

<sup>23</sup> Coniferales and Taxales.

<sup>24</sup> Magnoliopsida

<sup>25</sup> Liliopsida

<sup>26</sup> Gnetales.

### Further Reading

- Arnold, Chester A. (1944) *An Introduction to Paleobotany*. New York: McGraw Hill Book Co. Inc.
- Seward, Albert Charles (1931) *Plant Life through the Ages: a Geological and Botanical Retrospect*. Cambridge: Cambridge University Press.
- Stewart, Wilson N. and Gar W. Rothwell (1993) *Paleobotany and the Evolution of Plants*. Cambridge: Cambridge University Press.
- Taylor, Thomas N. and Edith L. Taylor (2009) *Paleobotany: the Biology and Evolution of Fossil Plants*. New York: Academic Press.

