

The Plant Kingdom and the Tree of Life

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We introduce children to the universe and feed their imaginations.
This includes our miraculous living world, the biosphere.

“For every complex problem there is an answer that is clear, simple, and wrong.”

– H. L. Mencken

Five Kingdoms is OUT and so is Six. They should be shown as part of the history of classification.

Past approaches – Linnaean ranks (kingdom, phylum, class, order, family, genus, species), based on the observable traits of organisms, shown as rows of evenly spaced boxes. Relationships within a rank were not indicated. This no longer gives children the concepts they need.

Current college textbook contents from eight introductory biology college textbooks

What was there:

- Tree of life or diversity of life
- Three domains – Bacteria, Archaea, and Eukarya
- Chapter on bacteria and archaea
- Chapter on protists, with some texts using “diversity of eukaryotes” instead
- Chapters on diversity of fungi, diversity of animals, diversity of plants

What wasn't in the eight college textbooks I checked:

- Very little mention of kingdoms
- The term “kingdom” did not appear in chapter or section titles.
- No use of the term “protocista”
- Formal Linnaean ranks such as Kingdom Animalia weren't used. Some use the term “phylum.” Many use a Latinized name without a rank – Amoebozoa, for example.

Classification has become systematics

- Systematics groups related organisms.
- The display of information is a branching diagram called a phylogeny.
- In plants, Linnaean ranks from orders to species are commonly used.

“Given the increasing use of phylogenies across the biological sciences, it is now essential that biology students learn what tree diagrams do (and do not) communicate.”

Baum, D. (2008) Reading a Phylogenetic Tree: The Meaning of Monophyletic Groups. *Nature Education* 1(1):190

A comment on terminology – traits are described as **ancestral** or **derived**. There have to be derived traits to produce a new lineage. A trait such as having four limbs is derived for the first tetrapods, but ancestral for all the subsequent lineages.

Rules for reading phylogenies

- Common ancestors are at the nodes.
- The lineages that share the most recent common ancestors are the most closely related.
- Extant organisms are at the ends of the branches.
- If we can't tell which branching happened first, then three or more branches arise from the same place.

What should children understand from about branching diagrams?

- Extant organisms have ancestors.
- We group organisms that share an ancestor.
- To be valid, a branch or lineage must hold all the descendants of an ancestor, and only that ancestor's descendants.
- The organisms that share the most recent common ancestor are the closest relatives.

Nesting and branching diagrams help children learn about tree diagrams.

The Tree of Life diagram is the big overview that comes first

The plant kingdom starts with the embryophytes

Bryophytes – need moisture to reproduce

- Hornworts – one chloroplast; cyanobacteria inside fix nitrogen; may be the first branch
- Liverworts – two forms, thalloid and leafy; sister lineage to the mosses; may have had stomata and lost them.
- Mosses – variety of sizes in the mm range; sporophytes start green and turn brown; found in most locales.

Tracheophytes – two lineages

- Lycophytes (zosterophylls, *Lepidodendron*, club mosses, spike mosses)
- Euphyllophytes (trimerophytes; fern clade; seed plants – Spermatophytes)

How have the pteridophytes (aka ferns and fern allies) changed?

- The phyla names are not used.
- Club mosses are a different lineage than the ferns and their relatives.
- Ferns are more closely related to the seed plants than they are to lycophytes.

Fern clade of the euphyllophytes

- “True leaf” plants date from early Devonian
- The fern clade is also called the **monilophytes**
- Three main branches
 - **whisk ferns** + adder's tongue & grape ferns
 - Equisetums – **horsetails**, scouring rushes
 - **true ferns**, also called leptosporangiate ferns, includes aquatics, tree ferns, epiphytes

True ferns have fiddleheads

- Fern growth forms – simple, compound, or bipinnate leaves
- Most ferns have rhizomes, underground stems.
- Leaves emerge from near soil level.
- Tree ferns have above-ground stems.
- Floating ferns have roots that hang down into the water.
- Sori hold fern spores

Euphyllophytes: seed plants

- Spermatophytes (seed plants) arose in the late Devonian from the progymnosperms
- Seed “ferns” were early seed plants.

Extant (currently living) lineages:

- Cycads
- Ginkgoes
- Conifers
- Gnetophytes
- Flowering plants, also called the angiosperms

Cycads have stiff leaves

Ginkgo biloba, the last survivor

Gnetophytes – survivors in three lineages

- *Ephedra* is dioecious.
- *Welwitschia mirabilis*, from the Namib Desert
- *Gnetum* is genus of vines and small trees in the tropics

Conifers are the most common gymnosperms

- How can you tell it is a conifer?
- It is a woody plant.
- It has cones, two types, which may be on the same tree or two different trees.
 - Seed cones (ovulate cones) are usually larger and stay on the tree longer, up to years.
 - Pollen cones are usually smaller. They fall off the tree after they shed their pollen.

Pines take two years to mature their seeds.

Angiosperm phylogeny

Waterlilies

Austrobaileyales (bay star-vine, star anise)

Magnoliids

Monocots

Eudicots

Structuring botany around families of flowering plants

- Knowledge of flowering plant families is portable – one can use it anywhere.
- Learning the families of food plants has practical applications.
- Children can learn flower structures as they study flowering plant families.
- Identify local plants by name and flowering plant family.

Books:

Elpel, Thomas. 2005. *Shanleya's Quest: A Botany Adventure For Kids Ages 9-99*. HOPS Press – Pony, Montana. Also *Botany in a Day*, the 2013 sixth edition.

Bayton, Ross and Simon Maughan. 2017. *Plant Families: A Guide for Gardeners and Botanists*. Quarto Publishing, University of Chicago Press. This is illustrated with attractive, accurate drawings. The information includes the history of the families and number of their members.

Food plant families and organic gardening

Crop rotation: Plant crops from the same family in a different area each year.

This improves disease resistance and slows nutrient depletion.

Families that need to be rotated include:

- Brassicaceae – cabbages, broccoli, radishes
- Solanaceae – tomatoes, potatoes, peppers
- Fabaceae – beans and peas
- Cucurbitaceae – squash, cucumbers, melons

The sunflower family, Asteraceae

- It is the largest family of flowering plants.
- The composite head has two different types of flowers, ray flowers and disk flowers.
- There are no sepals. The bracts beneath the head are the involucre; each is a phyllary.

The grass family, Poaceae (or Gramineae)

- The flowers are usually within bracts.
- The perianth is reduced to tiny scales.
- The stamens dangle in the wind. There can be one to three of them.
- The stigmas are feather-like.
- The ovary holds a single seed.
- The fruit is a grain.

Specimens for plant kingdom study

Mosses are easy to grow in a terrarium. They can be collected from places they are not wanted and transplanted onto moist potting soil. Make sure the terrarium gets lots of light, but is not in direct sunlight, which will overheat and fry the inhabitants. If you can't find mosses otherwise, ask a florist to get some for you. The florist trade does not necessarily harvest mosses sustainably, however. Mosses are available from science suppliers.

Liverworts can often be found on the surface of the soil in greenhouse pots. You may be able to get them for free if you ask. You can also order them from science suppliers. In moist areas, you may be able to find liverworts that you can transplant into a terrarium.

Hornworts are not so easy to find or obtain. I have not found a commercial source for them. There is a common aquarium plant called a hornwort, so do not confuse the two. The aquarium plant has stems with bottlebrush-like foliage. Its scientific name is *Ceratophyllum*. The hornworts that are bryophytes are genus *Anthoceros* and several other genera that end in *-ceros*.

Lycophytes include club mosses (*Lycopodium*) and spike mosses (*Selaginella*). Several species of *Selaginella* are available as house plants.

Equisetums – gather and dry your own.

Whisk ferns and relatives – some are available as potted plants. *Psilotum* and *Botrychium*

Ferns – See Carolina Scientific for culture kits.

Cycads are available as houseplants. The genera include *Cycas* and *Zamia*.

Ginkgo – if you can't plant one on the school grounds, you can press and dry the leaves. A dwarf variety is available.

Gnetophytes – in arid areas you can grow *Ephedra* species.

Conifers – the cones and dried branches make good specimens. Cone collections have many uses.

Angiosperms – try for a variety of the lineages in your landscape plants.