VASCULAR PLANT MORPHOLOGY
LABORATORY 7

Systematics and Phylogeny of Lignophytes;
Seed Plants plus Progymnosperms

Lignophytes are a clade of vascular plants that consists of seed plants and progymnosperms (a paraphyletic assemblage from which the seed plants arose). It is thought that by the transition from free-sporing heterospory to gymnospermous reproduction that the gymnosperms were derived from the progymnosperms. In this lab we will characterize the progymnosperms by the features of *Archaeopteris* of the Archaeopteridales and then look at the characters that changed in the evolution of the earliest seed plants, the seed ferns. The latter are represented in this lab by the most ancient seed fern that has been reconstructed to date, the Upper Devonian *Elkinsia polymorpha*. The general relationships among progymnosperms and seed plants are illustrated in the following cladogram from a recent cladistic analysis of lignophytes.

The Class Progymnospermopsida was proposed by Charles B. Beck in 1960 for plants that have vegetative feature similar to those of seed plants, but have reproduction like that of other free sporing pteridophytes. There are three orders of progymnosperms: Archaeopteridales, Aneurophytales and Protopityales. As illustrated on page 336 of Gifford and Foster (1989), *Archaeopteris* was a large, much-branched tree with small fan-shaped leaves. The leaves of some species were highly dissected. Based on plant habit, *Archaeopteris* looks a lot like a conifer, but much of the resemblance is superficial. While *Archaeopteris* had an eustele and lateral growth from a bifacial vascular cambium and cork cambia, it did not have axillary branching. Instead, branching was apical, like typical pteridophytes, and the branches were borne in the same helix with the leaves. We do not know if *Archaeopteris* had bipolar growth, or whether it had a globular embryo or a cotyledonary embryo. How do you think these features would effect the way an *Archaeopteris* tree grew?

The wood of *Archaeopteris* is preserved in large logs that are given the name *Callixylon*. The wood looks like conifer wood, but it has bordered pits arranged in distinctive groups on the radial walls of the tracheids. This **grouped pitting** is a characteristic feature of *Callixylon* wood, and it is not found in the wood of gymnosperms. Examine a block of *Callixylon* wood. Note how much like conifer wood it appears. Now examine a radial section of the wood, and find the grouped pitting. Draw a segment of the wood that shows both the grouped pitting of the tracheids and also some ray cells.

Examine a cross section of an *Archaeopteris* branch. Although the stem is flattened, you can make out the pith region and find the zone of wood. Now look at the inner margin of the wood for the mesarch bundles of the eustele that characterize *Archaeopteris*. Diagram the stem in cross section.

Examine a leafy branch of *Archaeopteris*. Locate the leaves and try to interpret how they are arranged. Draw the leafy branch system.

Now examine a fertile branch system of *Archaeopteris*. Note that the elongated sporangia stand upright from the adaxial surface of the sporophylls. Megasporangia and microsporangia apparently are mixed on the leaves, but it is difficult to interpret which is which until you macerate the spores from the sporangia. Draw a segment of the fertile branch system. Now draw a close up of one fertile leaf that shows several sporangia.

The Most Ancient Seed Plants; Pteridospermales

Members of the extinct Order Pteridospermales are commonly referred to as seed ferns. They lived from the Upper Devonian to the Jurassic. Seed ferns formed the ancestral group from which the Cycadales and all other seed plants arose. In cladistic terminology, seed ferns are a parphyletic assemblage that occur at several nodes near the base of the stem on the lignophyte tree (find these relationships on the lignophyte cladogram).

In this laboratory we will examine only material from the most ancient seed fern *Elkinsia*, and

then look at specimens that show various degrees of megasporangial enclosure by integumentary lobes (i.e., a transformational series illustrating the origin of the integument). This brief treatment of an extremely large and diverse group will serve to give you an idea of the earliest seed plants, and some feeling for the evolution of the integument.

Elkinsia polymorpha

Examine the reconstruction of the *Elkinsia* plant. Note that it consists of an unbranched stem from which fern-like fronds diverge in a helical arrangement. Examine specimens of Elkinsia stem and frond material that are compressed on the rock surface, or have been removed from the rock surface for further preparation. Note the slender, unbranched nature of the stem and the helical arrangement of the fronds. Also note that fronds are dimorphic. That is to say that some are vegetative, terminating in pinnately arranged pinnules, while others are forked throughout and terminate either in cupulate preovules or in clusters of pollen sacs. **Be extremely careful with this material!** It is the only material of *Elkinsia*, and the material upon which the concept of the most primitive seed ferns is based.

Examine the demonstration specimens and slides of *Elkinsia* vegetative and fertile remains. Note the anatomy of the stem. Is there secondary xylem (wood)? Now examine preparations and reconstructions of the cupulate preovules. Be sure that you understand what the various parts are, and how they work. Make drawings of those organs that you consider necessary to help you remember the important features of *Elkinsia*. Particularly important are the feature of the preovules. These will be used as an early stage in the transformational series that leads to fully integumented, indehiscent megasporangia (seeds). What was the propagule and how was it sealed after pollination in *Elkinsia*?

Seeds or ovules of the Lyginopteridaceae illustrate additional stages in the evolution of the integument. None of the most primitive forms with separate integumentary lobes are available, but two of the more advanced stages are. In the genus *Tyliosperma* the lobes of the integument are fused at the base of the preovule, and free at the distal end. Is there a micropyle in this type of preovule?

Examine a transverse section of *Tyliosperma* near the base of the preovule. Now examine a section from closer to the apex. Diagram the ovule as seen in each section, and then draw the ovule from the outside as you have reconstructed it in your mind.

Ovules with completely fused integumentary lobes are more like the seeds of extant plants. Examine the demonstration specimen of the genus *Conostoma* in mid-longitudinal section. Sketch the ovule. Identify the integument, micropyle and nucellus. Note the complicated structure of the pollen chamber.

Review the structure, growth and life cycles of a free-sporing pteridophyte and a seed plant to be sure you understand the similarities and differences. Also, review the structure of an ovule or seed to be sure you understand the homologies of the parts. **Ask if you don't understand.**