IX. Seed Ferns and Cycads

We now move on to the first seed plants of the course! We will discover that the seed plants (the gymnosperms and angiosperms) are usually woody; the exceptions are among the flowering plants. They all appear to have megaphylls. An evolutionary line of seed plant progenitors is known from the Middle Devonian and true seeds have been found in the Mississippian, before the coal forests flourished. Hence, these plants have been around for awhile. We will study two groups of seed plants today,

1. Extinct coal forest seed ferns in the order Medullosales.

2. Living plants of the cycads, order Cycadales.

A. Seed Ferns: Medullosales

The Medullosales, or medullosans as they're called, grew right alongside Lepidodendron and Calamites in the coal forests and perhaps had Sphenophyllum climbing up their trunks. They look like tree ferns, but are not true ferns at all: they are woody and have seeds. It is likely that their megaphylls are not even homologous with those of the true ferns.

1. Begin by looking at foliage fossils preserved in Mazon Creek nodules and in the shale from Pennsylvania. Note that we are dealing with a highly divided megaphyll that looks like that of a modern tree fern, but is in fact the foliage of a primitive seed plant from the Carboniferous. It's remarkable how fernlike the megaphylls are. See if you can figure out how the leaves of the seed fern form genera *Neuropteris* and *Alethopteris* differ.

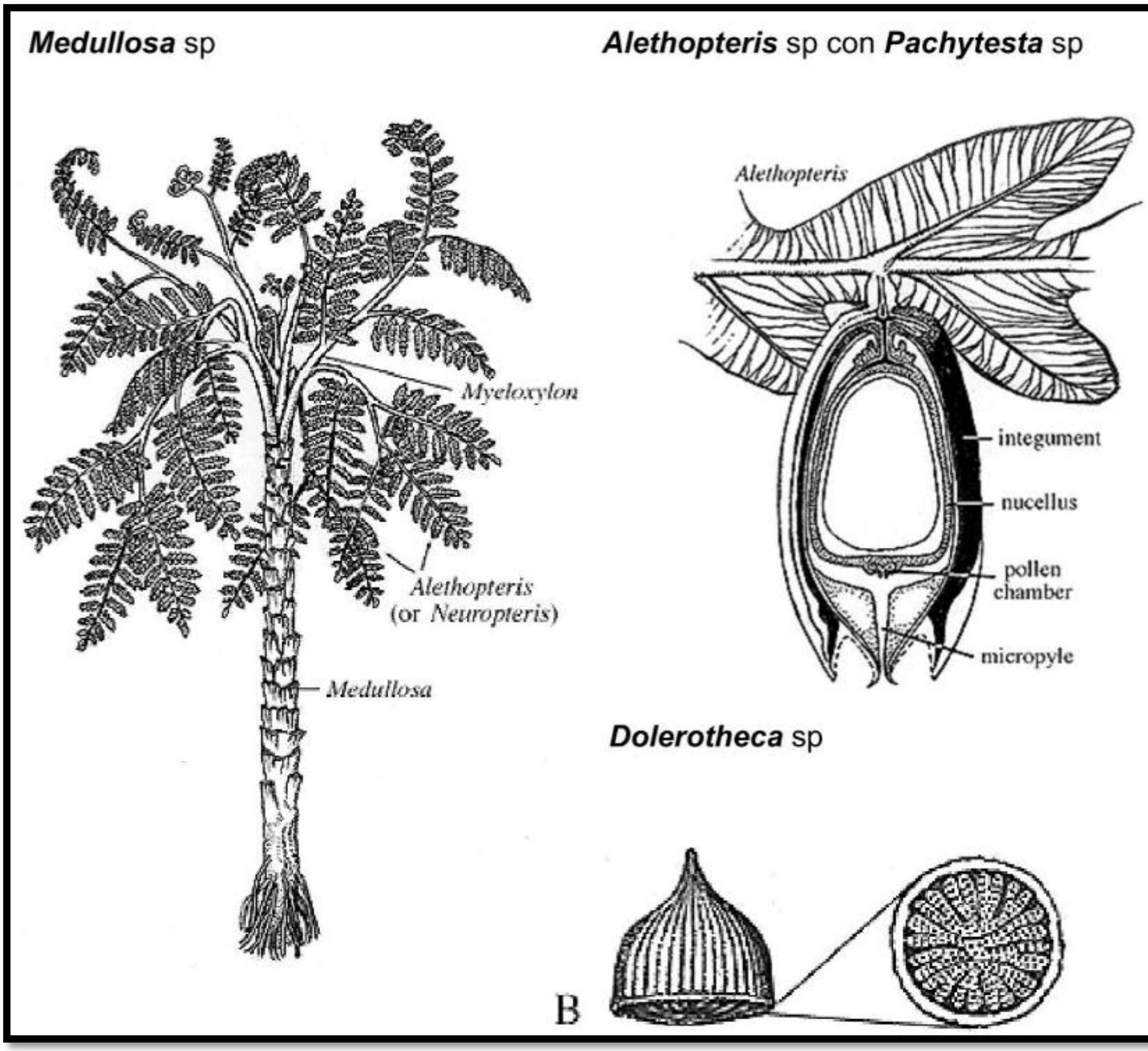
2. Peels of stem sections are also in the lab. Remember that in these fossil axes, some of the original material is missing, and some more is distorted in fossilization.

> a. Start by looking for three masses of secondary xylem in a triangle. It appears as though the stem has three separate steles, however paleobotanists argue that they each 'stele' actually represents a vascular bundle such as you might find in a modern eudicot stem. The difference is that each vascular bundle was equipped with its own vascular cambium! Now look at the xylem under your dissecting microscope. Notice that in contains many of vascular rays, radial rows of parenchyma. Wood that is rich in vascular rays is called manoxylic it is a derived wood type typical of seed ferns and cycads. These rays connect parenchyma within the stele to ground tissue surrounding the wood. The primary xylem and the pith within have been crushed during growth or fossilization.

b. Outside of the three secondary xylem masses is a group of about a dozen <u>periderm masses</u>, each produced by a <u>cork cambium</u> located to the inside of the periderm. The group of periderm bundles has been flattened during fossilization.

c. Finally, look for damaged remnants of the <u>primary cortex</u> outside of the periderm: the key feature of the outer part of the primary cortex is a checkerboard pattern of dark colored sclerenchyma bundles (packets of cells) and pale colored secretory ducts in a thin layer.

*S1. Sketch the peel of the *Medullosa* stem. Label the terms highlighted above.



3. Now look at peels of petioles (form genus *Myeloxylon*) in cross section. These petioles are dramatically different from the rest we've seen, simply because they are so large. Notice the numerous <u>leaf traces</u> (not just one or a few) and the <u>sclerenchyma cells</u> near the surface of the petiole. These large petioles doubtless had quite a challenge holding the huge seed fern leaves up in the air.

4. Peels of a seed fern seed (*Pachytesta*) are common in coal balls. The seeds are large – about the size of a pecan! The diagram on p. 352 of Gifford and Foster will help you to interpret this interesting structure. So what is the homology of the seed? The most commonly accepted interpretation is that the seed is a megasporangium surrounded by an integument, which is homologous with a set of branch trusses. A single megaspore develops into a female gametophyte completely inside of the mega-sporangium wall (also called a nucellus). These gametophytes have typical archegonia with eggs, which, upon fertilization, develop into embryonic sporophytes inside the seed, using the tissue of the female gametophyte as a nutritional resource.

a. In the transverse section, the <u>integument</u> with its distinctive inner, dark layer and its outer, pale layer are recognizable from the start. The outer pale layer appears to have been fleshy suggesting that these seeds were animal dispersed!

b. In the longitudinal section, the integument is not as clear, but you should be able to identify it based on your experience with the transverse section. However, the <u>megasporangium wall</u> is better seen in this section. The megasporangium wall, also called the <u>nucellus</u>, lies loose within the integuments. No embryo or gametophyte is preserved.

*S2. Sketch *Pachytesta* in longitudinal and transverse section. Compare the two by highlighting the terms above that are visible in both.

B. Cycads: Cycadales

The living cycads are a typical example of a relictual group, that is, a group with few species occupying small geographic ranges relative to their fossil counterparts. In fact, the cycads were an extremely important part of the vegetation in Mesozoic times fossils are common and diverse.

In general, the cycads look like palm trees (which are angiosperms), but they have seeds on leaves or in strobili, not enclosed in fruits (like dates or coconuts) as the p alms do. Cycads grow in tropical regions only, but they are found in a diversity of habitats, from deserts to rain forests.

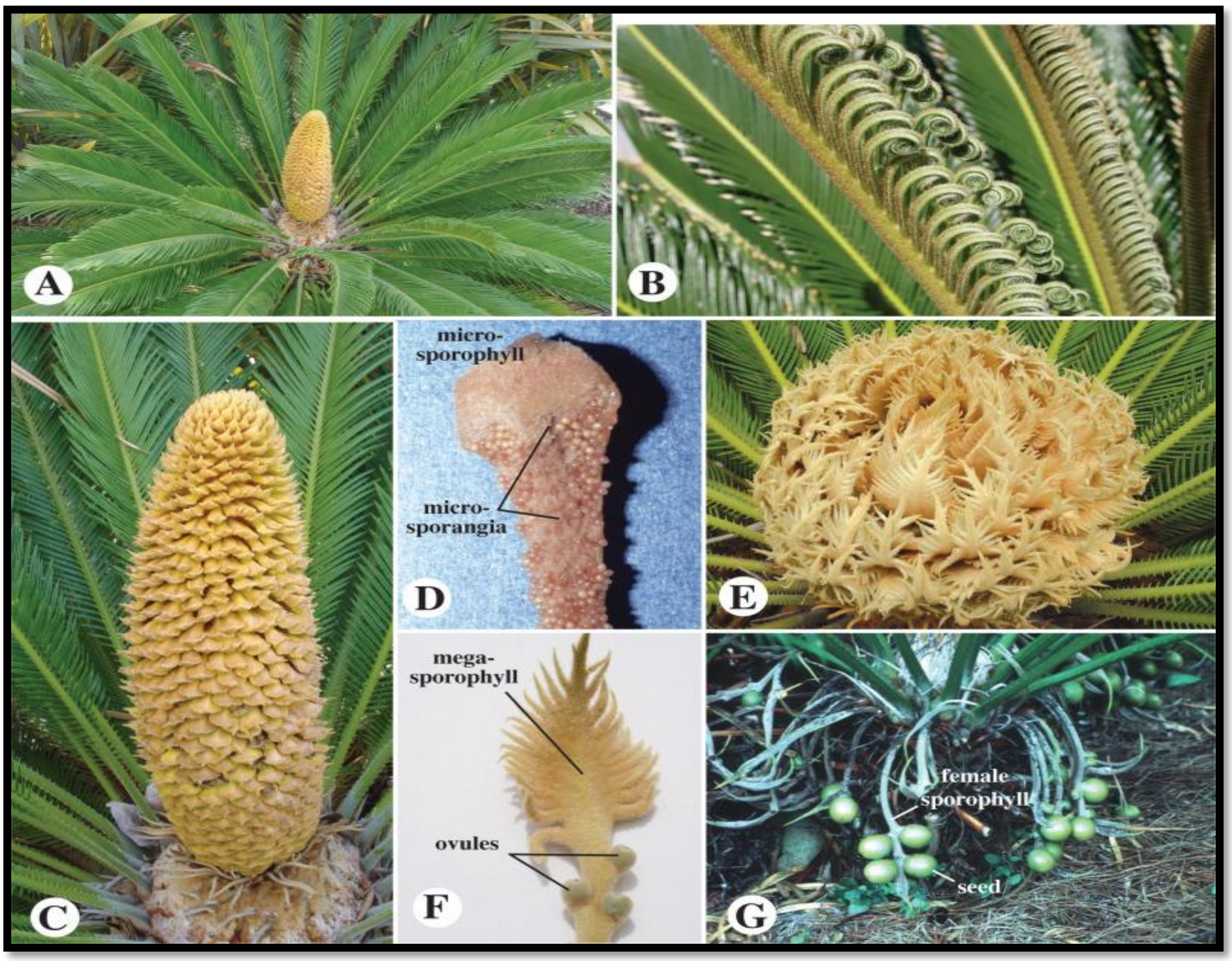
1. Living Plants: Go to the greenhouse to see the cycads. From the plants in the greenhouse you should be able to get an idea of the life form of these plants.

a. First examine *Cycas revoluta*, near the bench beside the fountain. Notice the palm-like look, the <u>stem</u> covered with the scars of old leaves, and the single crown bearing numerous <u>once-pinnate leaves</u>. These are all typical cycad features. Now look more closely.

i. At the base of the stem are round <u>buds</u>, all capable of generating small new plants. (The very cycad you are admiring was started from such a bud, produced by a big old female that had been living in the greenhouse for decades.) Climb up on the bench and gaze down on the shoot apex. Interior to whorl of leaves, find a whorl of <u>cataphylls</u>, abortive leaves covered with stellate hairs that provide protection to the growing shoot apex. Touch one lightly to see how good they must be at doing that! Now find, interior to the cataphyll whorl, a set of small fuzzy structures lacking spines: what are these?

ii. This is a female plant; were it more mature, you would find a set of modified ovule-bearing leaves such as you see in panel **F** in the photographic plate below. Borne along the petiole would be a set of ovules; if a male cycad were around to provide pollen, they would develop into fleshy seeds like those in the picture.

b. On the other side of the conservatory, find a cycad in the genus *Zamia*. Female plants in this genus produce their ovule-bearing structures in cones. Male plants also produce cones, bearing microsporangia in which pollen is produced. Is this plant a male or a female? How do you know?



2. Now, back in the laboratory, look at prepared transverse (cross) sections of cycad stems. These have been prepared from young cycad shoots, so that a single slide includes almost all of a stem cross section.

a. Locate the <u>stele</u> and its secondary growth by looking for lines of radiating, red staining <u>tracheids</u>. Note that the amount of secondary xylem is limited and that the number of tracheids is small and that there is a lot of <u>parenchyma</u> in among the tracheids. Once again, this is the typical <u>manoxylic</u> wood of cycads and seed ferns.

b. Also look for leaf traces outside the wood that are cut in longitudinal section, though this is a transverse section of the stem. These are the typical girdling leaf traces of cycads they wind around and around the stem cortex before passing out into the leaf bases.

c. Secretory ducts, with or without their mucilage contents, are visible here and there in the cortex and pith.

***S3. Sketch of the transverse AND longitudinal section of the cycad stem from the prepared slides. Label the terms highlighted above.**

3. Look at pickled microsporangiate strobilus of a cycad, either *Cycas* or *Zamia*.

Choose a microsporophyll:

a. Place it on the dissecting 'scope stage.

b. Note that the microsporangia are eusporangia, that they are abaxial, and that they are either spread over the undersurface or grouped in sori, like ferns.

c.. Look at pollen grain (immature male gametophyte) removed from one of the sporangia under the compound microscope. This monosulcate pollen, with one groove through which the pollen germinates, is common among gymnosperms and even some angiosperms.

***S4. DIAGRAM a cycad microsporophyll. You can sketch either *Cycas* or *Zamia*. Label the terms highlighted above.**

4. Next, do the same set of observations for an ovule-bearing strobilus. Share one megasporophyll with someone else in the lab. Note that the seeds (mature ovules with embryonic sporophytes) are borne on the peltate (umbrella shaped) megasporophyll. Look for a small black dot at the other end of the seed from its attachment this dot is the micropyle, literally the little gate, through which the pollen is drawn to the neighborhood of the female gametophyte.

5. To get a better sense of how the ovules are arrayed on megasporophylls in the strobilus, study a prepared slide of a young *Zamia* cone under the microscope.

6. Now choose a mature cycad ovule from those set out on the lab table. They look kind of like wrinkled red plums.

a. Make a careful longitudinal section with a razor blade, right down through the micropyle. (The seed is tough; be firm and careful.)

b. Starting from the outside, identify three integument layers:

i. the outer, fleshy layer of the integument, called the sarcotesta.

ii. the middle, stony layer of the integument, called the sclerotesta.

iii. the inner, papery layer of the integument, called the endotesta.

c. Inside the integument lies the female gametophyte, which you should pop out of its place in the integument. Look for:

i. a thin membrane that remains with the integument, near the micropylar end: this is the free, unfused portion of the nucellus (the megasporangium wall)

ii. a small embryo or cavity left where it was located in the micropylar end of the female gametophyte

iii. The remainder of the soft interior tissue is all haploid cells of the female gametophyte.

***S5. From the dried seeds, sketch the seed in longitudinal section, and then sketch the interior parts.**

7. Finally, use a *dissecting* microscope to examine a prepared slide of the cycad ovule. Note the central female gametophyte.

a. Outermost is the <u>integument</u>: look for the stony and fleshy layers once again the papery layer is distinguishable at the point where the integument separates from the megasporangium, that is the <u>nucellus</u>. At the micropylar end of the ovule, the nucellus is a dozen cells thick.

b. The nucellus encloses the <u>female gametophyte</u>. Find the large <u>archegonia</u>, most of which is <u>egg cell</u>.

c. In order to see more detail, look at the same slide with a *compound* microscope. Note the <u>neck cells</u> of the archegonia. Find also the large, irregular shape of the <u>pollen grain</u> that is germinating on the nucellus.

***S6. Make a diagram of the cycad ovule from the prepared slide (dissecting 'scope). Include a close up showing details of the archegonia and the nucellus (compound 'scope). Label the terms highlighted above.**