I. Cycadales

A. General Organography

Cycads represent among the most primitive of the seed-bearing plants on both vegetative and reproductive grounds. Observe living specimens of the following:

- *Ceratozamia mexicana*
- *Cycas circinalis*
- *Cycas revoluta*
- *Dioon spinulosum*
- *Stangeria paradoxa*
- *Zamia floridana*

(We do not have living specimens of the other genera at present, for example: *Bowenia*, *Encephalartos*, *Microcycas*, *Macrozamia*.) For each of the above examine the large frond-like leaves, noting how the leaves form a crown at the top of the stem. Locate the leaf bases (sometimes called cataphylls) remaining as armaments on the trunk. What general phyllotaxis is exemplified by these cycads? What type of vernation is shown by each pinna? Do cycads ever produce sizable lateral branches? Locate the apogeotropous roots growing upward out of the soil. What is their significance?

B. Stem Anatomy

Obtain a large prepared slide of a transverse section of the genus *Zamia*. Locate the pith, vascular cylinder, secondary xylem, phloem, cortex girdling leaf traces and epidermis. Is this stem pycnoxylic or manoxylic? Notice that the rays within the secondary xylem are quite wide. Have you been able to follow the course of one of the leaf traces? Do leaf gaps occur in the primary xylem of the stem?

C. Anatomy of a Leaflet

Obtain a prepared slide showing a transverse section of the leaflet of *Zamia*. Locate the upper epidermis, hypodermis, mesophyll, vascular bundle, xylem, phloem and bundle sheath extension. Is this type of vascular system characteristic of all cycads? Compare the venation patterns of the various living species which you have examined in part IA. Especially notice the leaflets of *Cycas revoluta* which has only a single midrib and which lacks vascularization of the wings of the lamina.

D. Roots

Did you notice the general organography of the root system when you examined the plants previously? Obtain prepared slides of transverse sections of both *Cycas* and *Zamia* roots, as available. What pattern of xylem is manifested in these species? Do any of the living specimens produce aerial roots with endophytic algae. If so, make a free-hand section of the root and locate the area of algal infection.
II. Ginkgoales

A. General Organography

Observe the living specimen of the maidenhair tree *Ginkgo biloba* which may just be beginning to produce this year's foliage. We will have to take a walk to do this though, because it is located outside the President's office. Observe the pattern of irregular branching which is customary in *Ginkgo*. Pay particular attention to the dimorphic pattern of branching and sketch the morphology of the short shoot system. Are leaves borne on both the long and short "spur" shoots? Make a longitudinal section of one of the short shoots obtained from a living tree. Locate the leaf primordia. Examine each individual leaf and note the amount of lobing and the general shape. What type of venation pattern is expressed in these leaves?

B. Anatomy of the Stem

Obtain a prepared slide showing the cross sectional anatomy of the manoxylic short shoot of *Ginkgo*. At older stages in stem morphology the stem is occupied largely by secondary xylem. At this early stage of development the stem of *Ginkgo* looks almost like a mature section of the *Zamia* stem you saw earlier in lab. Can the concept of neoteny be used to explain the manoxylic wood of *Zamia*? In *Ginkgo* locate the pith, secondary xylem, secondary phloem, and cortex. Obtain a section of a twig from a long shoot of *Ginkgo*. Notice that the secondary xylem is well expressed in the long shoot and pycnoxylic development is amply manifested.

C. Anatomy of the Leaf

*Ginkgo* seems unique among gymnosperms in showing a peculiar seasonal heterophylly. Leaves produced early in the season originate during the previous season, overwinter, and are rapidly exposed and develop as soon as the bud breaks in the spring. The late leaves are those leaves which are formed during the spring and summer but whose primordia are not present in the over-wintering bud. Obtain herbarium specimens showing this phenomenon. Sketch a typical early leaf and a typical late leaf and other manifestations of this heterophylly. Obtain a prepared slide of a cross section of the leaf of *Ginkgo*. Identify the component cells and tissues of the leaf.

III. Morphology of the Cycad Cone

In the next lab we will begin to examine the morphology of the ovule and seed; however, it seems appropriate to examine the organization of the strobilar axis and its modified leaves at this time. Whatever you don't finish today you can finish next time.

A. Comparative Morphology of the Microsporangiate Strobilus

Study and draw the structure of the microsporangiate strobili of the various cycads in the lab. What is the phyllotaxis of the strobilus? Does it differ radically from that of the main axis? Obtain individual microsporophylls of *C. revoluta* and other species. Draw the structure of the microsporophylls and the pattern of distribution of microsporangia. Is the microsporophyll homologous with a foliage leaf? What evidence would you cite in support of this viewpoint? How has this organ been modified in relation to the differentiation of the strobilus?
B. Comparative Morphology of the Megasporangiate Strobilus

For each of the following species as available, draw the gross structure of the megasporangiate strobilus and indicate their normal position on the shoot apex.

*Cycas circinalis*
*Cycas revoluta*
*Dioon spinulosum*
*Ceratozamia mexicana*
*Zamia floridana*

Is there any indication that megasporophylls may also represent modified foliar organs? Arrange the above sporophylls in a typological series of what you believe to be the direction of specialization of cone appendages and strobilus differentiation.