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(15) 1. Each of the genera below have had central roles in elucidating the evolutionary relationships of land plant groups. For each, give a brief description of its morphology, organography, and salient points of its anatomy. Then explain how it is linked to understanding the plant group(s) to which each is associated.

(a) *Asteroxylon*
(b) *Ibyka*
(c) *Renalia*

(30) 2. Complete TWO of the following three comparisons:

(a) Compare and contrast strobilus organization and structure in the primitive, urostachyoid (*Huperzia*) and advanced, rhopalostachyoid (*Lycopodiella, Diphasiastrum, Lycopodium*) members of the genus *Lycopodium*.

(b) Sketch and explain the anatomy and mode of secondary growth in the genus *Isoetes*. Why is this unusual compared to other higher plants?

(c) Explain the importance of anisospory in *Equisetum* in relation to the evolution of heterospory in the sphenophyte line.

(20) 3. Define and explain the botanical significance of the following terms:

(a) form genus
(b) protoxylem lacuna
(c) foot
(d) distachous
(e) actinostele
(f) lateral anisophylly
(g) serial homology

(15) 4. From which group (or groups) did the vascular land plants originate? (1) Explain the evidence for this origin. (2) What modifications of their structure are required in order to obtain a typical primitive land plant. (3) When did land plants originate (geological period and approximate age)?

(20) 5. Construct and defend an evolutionary scheme among six hypothetical species of *Equisetum*. First, draw and "name" your "species". Second, diagram evolutionary relationships among the species. Third, explain how this exercise relates to the concept of typology.
1. Answer TWO of the following three questions:
   (a) Outline the major evolutionary changes that would have been required to have converted a heterosporous free-sporing plant like *Selaginella* to the seed habit as it occurs in the gymnosperms.
   (b) Sketch and discuss the fossil evidence regarding the origin of the integument in the gymnosperm ovule. Of what significance is the cupule among the fossil plants studied and how did it originate?
   (c) Outline the various types of siphonosteles discussed in class (*with* sketches) indicate their relationships, and discuss which types are believed to be the most advanced.

2. (a) Construct and defend an evolutionary scheme among the extant (living) orders of ferns. Present *all important evidence* available to support your scheme. (b) Discuss whether you believe that the ferns are a monophyletic or polyphyletic group and provide support for your interpretation.

3. Define and explain the botanical significance of the following terms:
   (a) compound strobilus
   (b) *Calamites*
   (c) hypogeal germination
   (d) coenosorus
   (e) pycnoxylic
   (f) telome theory
   (g) *Lagenostoma*

4. Complete TWO of the following three comparisons:
   (a) Compare and contrast the vegetative and reproductive organization of the orders Pinales and Taxales in the Coniferophyta.
   (b) Compare and contrast the female strobilus of *Cycas* with that of *Pinus*. Are these two structures entirely homologous? Why or why not?
   (c) Compare and contrast sexual reproduction and fertilization in *Marsilea* with that of any member of the Filicales.

5. Outline the sequence of reproductive events in either *Pinus* OR the cycads from initiation of the seed (megaspore mother cell) through fertilization to the mature seed. Which did you select (cycad or pine)? How much time does this process take?
(20) 1. Answer ONE of the following three questions:

(a) In the lab, we observed a variety of transitional leaf forms present in winter buds. Morphologically, what do these leaves represent and how do these relate to the various leaf zonation concepts that we discussed in class.

(b) Based on morphological trends in the angiosperms, reconstruct a "primitive" angiosperm. Please discuss the major floral and vegetative morphological characteristics expected in this flowering plant.

(c) Discuss the major growth habits and morphological patterns of adaptation to the aquatic environment.

(20) 2. Define and explain the botanical significance of the following terms:

(a) hemiepiphyte

(b) fractals in nature

(c) double fertilization

(d) orthostichy

(e) atactostele

(f) Oberblatt

(g) prophyll

(40) 3. Complete TWO of the following three comparisons:

(a) Compare and contrast double fertilization in *Ephedra* with double fertilization in the angiosperms. What does this mean in an evolutionary sense?

(b) Construct a typology accounting for the vascular organization of the stem and root of monocots and dicots starting with a common ancestor.

(c) Compare and contrast female gametophyte formation in a typical monosporic angiosperm with that of a tetrasporic one. Please label fully. What "types" did you draw?