SECTION 1 (Short answer; 56 points total): Read the questions carefully. Be as precise as possible in your answers.

1. Identify the lettered parts (a-e) of the unfertilized gynoecium shown here and then answer the questions below. 16 points total (2 points each)

   What is a. derived from in an evolutionary sense (or, another way, what is it homologous to)?

   What will b. become when this gynoecium is fertilized?

   What will c. become when it is fertilized?

2. You have seen examples of independent, repeated evolution (homoplasy) of many different traits. Four of these are listed below; fill in families that exhibit these traits (or that include genera or groups of genera that exhibit these traits). 8 points total

<table>
<thead>
<tr>
<th>Trait(s) showing convergence</th>
<th>Family #1</th>
<th>Family #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem succulence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pollinia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind pollination</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3. Match each taxon on the right with the most appropriate adaptation (or set of adaptations) from the column on the left. Put your answer in the 2nd column. **Each taxon and adaptation must be used only once.** (1 point each, 12 points total)

<table>
<thead>
<tr>
<th>Adaptation</th>
<th>Answer</th>
<th>Taxon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gynobasic style/nutlets</td>
<td>A –</td>
<td>Poaceae</td>
</tr>
<tr>
<td>Nitrogen fixation in root nodules</td>
<td>B –</td>
<td>Apiaceae</td>
</tr>
<tr>
<td>Spathe and spadix</td>
<td>C –</td>
<td>Nymphaeaceae</td>
</tr>
<tr>
<td>Latex, unisexual flowers</td>
<td>D –</td>
<td>Orchidaceae</td>
</tr>
<tr>
<td>Bulbs, sulphur-containing compounds</td>
<td>E –</td>
<td>Asteraceae</td>
</tr>
<tr>
<td>Labellum and pollinia</td>
<td>F –</td>
<td>Fabaceae</td>
</tr>
<tr>
<td>Tetradymanous stamens</td>
<td>G –</td>
<td>Araceae</td>
</tr>
<tr>
<td>Floating aquatic/beetle pollination</td>
<td>H –</td>
<td>Polygonaceae</td>
</tr>
<tr>
<td>Caryopsis and specialized embryo</td>
<td>I –</td>
<td>Euphorbiaceae</td>
</tr>
<tr>
<td>Inflexed petals and a stylpodium</td>
<td>J –</td>
<td>Lamiaceae</td>
</tr>
<tr>
<td>Ocrea; tepals</td>
<td>K –</td>
<td>Alliaceae</td>
</tr>
<tr>
<td>Head; ray and disk florets</td>
<td>L –</td>
<td>Brassicaceae</td>
</tr>
</tbody>
</table>

3. Give two reasons why plant names change. 4 points

4. The development of DNA sequencing techniques revolutionized plant systematics. Give two reasons why molecular (DNA) sequence data are considered to be superior to traditional morphological data in terms of character number and number of character states. Why do we still study the morphology of plants? 6 points

Page 2
5. What is a pseudanthium? What are the two examples of pseudanthia that we have studied this semester? Pick one of them and explain the structure of the pseudanthium in more detail. 6 points

6. If you are doing a phylogenetic (cladistic) analysis of a group of organisms, you need to select characters for which the character states are considered to be homologous. What does the term “homology” mean in this context? 4 points

Bonus question (2 points):

What is the plant tissue that provides the nutritional basis for human civilization?
SECTION 2 (42 points total): Phylogenetics, Speciation, Nomenclature, Classification

Two intrepid botanists, Lakshmi Attigala and Elizabeth Bach, are collaborating to study the systematics and ecology of the western branch of the core tricolpate family Unowattiaceae, which consists of the three long-recognized, presumably closely related genera *Wattia*, *Cuzunowattia* and *Unowattia*. Lakshmi and Elizabeth have completed extensive field work in the xerophytic and montane habitats occupied by this group in the Southwest U.S. They find what appears to be a total of 9 species and, because they are thorough, well trained systematists, they conduct a molecular phylogenetic analysis based on five chloroplast regions in addition to studying morphological variation within the three genera, conducting a common garden/crossing experiment, and counting chromosomes. The phylogeny they recover, with maximal support for all branches, is shown on the handout, along with the morphological synapomorphies and other character state changes that they found. The genera and species names along with their dates of publication are:

- *Wattia* Wallace 1916
- *Wattia wanta* Wallace 1916
- *Wattia needa* M. Clark 1916
- *Wattia nowa* Beaman 1930
- *Wattia mexicana* Beaman 1930
- *Wattia kiddina* Wendel 1956
- *Unowattia* Wallace 1915
- *Unowattia occidentalis* Wallace 1915
- *Unowattia donchua* Wallace 1925
- *Cuzunowattia* M. Clark 1938
- *Cuzunowattia occidentalis* M. Clark 1938
- *Cuzunowattia wattupia* L. G. Clark 1965

*Unowattia* and *Cuzunowattia* are characteristic of desert habitats in a region with lots of overhanging cliffs and caves. Species of *Wattia* are found in mostly dry habitats in mountainous areas along the bottoms of gullies or along water courses, often overlapping in range with species of *Unowattia* but rarely growing alongside them. Two species of *Wattia*, *W. needa* and *W. nowa*, grow along stream banks, with *W. needa* at lower elevations and *W. nowa* at higher elevations.

Careful study by Elizabeth and Lakshmi revealed variation in plant and flower size between *W. needa* and *W. nowa*, with plants and flowers of *W. nowa* becoming smaller with increasing altitude. Plants of *W. nowa* transplanted and grown at lower elevations were similar in size to *W. needa*, and plants of *W. needa* transplanted and grown at higher elevations were smaller than usual and similar to those of *W. nowa*. Crossing experiments showed complete fertility among all forms.

Lakshmi and Elizabeth also found a small population of purple-flowered plants growing in a desert gully near an extensive population of *W. wanta*. These plants had irregularly divided spines, weakly zygomorphic corollas, and lanceolate leaves with small teeth along the edges. Chromosomal analysis revealed a diploid chromosome count of 2n = 15 and chloroplast sequence data placed it within the *W. occidentalis/W. wanta* clade. Even with repeated visits at various times of the year, Elizabeth and Lakshmi never found mature fruits or seeds in this population.

1. *Unowattia* and *Cuzunowattia* are each clearly supported as monophyletic, but what phylogenetic term describes the status of *Wattia*? 2 points
2. Lakshmi and Elizabeth realize that they cannot maintain *Wattia* as a genus, at least not in its traditional concept. What are the two possible solutions to this problem? Which one would you choose and why? 8 points

3. Elizabeth and Lakshmi also decide that the differences traditionally used to separate *Cuzunowattia* and *Unowattia* are not sufficient to maintain them as two genera, and so they decide to recognize one genus with four species. Which generic name must they choose and why? What must happen to the name *C. occidentalis* and why? 6 points

4. What do you think the pollination system is in the *Cuzunowattia/Unowattia* clade? 2 points

5. What is your interpretation of the pattern of variation seen between *W. nowa* and *W. neededa*? Should they be maintained as two species or treated as one? Explain. If treated as one species, what is the correct name for the species? 6 points
6. Now let’s sort out that small population that Lakshmi and Elizabeth observed and sampled during their field work. How would you explain the derivation of the $2n = 15$ chromosome number in this population? Is its morphology consistent with what you know about the probable derivation of the chromosome number—how so? Which species is the maternal parent? From which species did the pollen donor come? 6 points

7. Should this population be described as a new species—why or why not? 4 points

8. Give one example of a synapomorphic character state for a clade within the Western Unowattiacae. Give one example of an autapomorphic character state in this cladogram. Give one example of a homoplasious character state. And give one example of a character state that has reversed to the ancestral condition. 8 points total, 2 points each.

Synapomorphic:

Autapomorphic:

Homoplasious:

Reversal to an ancestral state:

**Bonus question (2 points):**

What is the term applied to a set of evolutionary lineages (but not a monophyletic group) that has reached a similar level of morphological or physiological complexity?
SECTION 3 (Fill-in-the-blank or true-false; 2 points each, 52 points total). For each question provide the single best answer or clearly indicate whether a statement is true or false.

1. Land plants all share the _________________________________ life cycle, in which the diploid sporophytes undergo ___________________ (cell division) to produce haploid ________________ (cell type) that grow by mitosis into ______________________________ (life cycle phase) which produce gametes that ultimately undergo syngamy to directly produce a diploid zygote.

2. True or false: The fleshy fruits of Gingko were likely originally dispersed by dinosaurs.

3. Tricolpate pollen is a synapomorphy for the ________________ (major clade).

4. The presence of three or more complete sets of chromosomes in the nucleus of a body cell is known as ______________________.

5. True or false: Because Amborellaceae is sister to all other angiosperms, we can infer something about the characteristics of the common ancestor of all angiosperms by studying this taxon.

6. True or false: A flower with a hypanthium must have an inferior ovary.

7. True or false: Taxa with the succulent stem habit are well adapted to growing in dry habitats.
8. __________________________ and ________________________ are two synapomorphies for angiosperms.

9. The presence of one cotyledon, parallel-veined leaves and trimerous flowers are considered __________________ within the monocots.

10. A spathe, a cyathophyll or a phyllary would each be considered a modified ________________ (structure).

11. A compound ovary with 3 stigma lobes, 1 style and 3 locules would be inferred to consist of ____ carpels.

12. True or false: Sympatric speciation requires both geographic and reproductive isolation, whereas allopatric speciation requires only reproductive isolation.

13. Because a complete flower must be a __________________ (sexuality) flower, it follows that an imperfect flower must be an ______________________ flower.

14. A cladode must be homologous to a stem because it has both __________________ and ____________________.

15. The cotton fiber of commerce is produce by the ________________ (structure) of the cotton plant.
16. With regard to fruit dispersal, the perigynium in Carex is an adaptation for ____________ dispersal, whereas Asteraceae achenes with a feathery pappus represent an adaptation for ____________ dispersal.

17. Secondary growth in the form of wood is seen in many seed plant families including ________________ and ________________.

18. True or false: Chloroplast DNA is usually maternally inherited in seed plants.

Bonus question (2 points):

What plant am I?

You might think I’m explosive
With a name that starts like mine,
Or better yet, a greeting call
From a ghost that’s just behind.

And as I climb above you,
I also run below;
But will you see me flower?
I guess you’ll never know!