INSTRUCTIONS: Questions will be answered by computer as Microsoft WORD *.doc files (in the format of "student no_session_no.doc; for example, for student 67 responding to session 1, the file will be named “67_session_1.doc”). For any drawings that can’t be done on the computer, make note on your computerized response of any supplementary notes to be written on one side only of the answer sheet provided.

SESSION 1: Basic Plant Biology. Answer these 50 questions. Two points credit each.

Plant Physiology
1. What are aquaporins? What is the distribution of aquaporins across kingdoms?
2. What is the Casparian strip? What is its function? What is the name of the wax-like hydrophobic substance that impregnates the Casparian strip?
3. Briefly describe the differences between water transport via the apoplast and the symplastic/transmembrane pathways.
4. The xylem vessels conduct water and mineral nutrients in a basipetal direction (downwards). True or false? ______ Explain.
5. Briefly describe at least two ways in which plants minimize cavitation in the xylem vessels.
6. Mention two roles of magnesium in plants. Is magnesium a mobile or an immobile nutrient? Is it a micro- or a macronutrient?
7. What is an action spectrum? What is the relationship between the action spectrum for photosynthesis and the absorption spectrum of chlorophyll?
8. The herbicide DCMU (dichlorophenyl-dimethylurea) has an Em value of -0.446 V. How does DCMU interrupt the electron transport between P680 and P700?
9. What are the two main biochemical products of the thylakoid-associated reactions in photosynthesis? How are they utilized in carbon fixation reactions?
10. Is the photoconversion of phytochrome from Pr to Pfr (or vice versa) ever 100%? Explain your answer.
11. In what organs of a plant is indoleacetic acid synthesized? Why there?
12. The biosynthesis of gibberellins takes place entirely in the plastids. True or false? ______ Explain.
13. What is the biochemical nature of cytokinins? Why do cytokinins need to be added to media for plant tissue culture?
14. What is the physical state of the phytohormone ethylene? What is its antagonistic hormone in leaf shedding?
15. Mention two roles of abscisic acid during embryogenesis.

Plant Molecular Biology/ Genetics
16. Which approach, gain-of-function or loss-of-function, can provide more convincing evidence regarding the function of a gene or gene product? Why?
17. If two recessive early flowering mutants were crossed and the F1 showed normal flowering time, how would you explain it?
18. What is the relationship between the nuclear genome and the chloroplast genome?
19. Based on the computer program prediction, a novel plant gene does not contain any intron. Is this possible? How can you test it?
20. If a gene is known to be functional in Arabidopsis and rice, how can you clone its ortholog from barley in which its sequence information is not yet available?
21. What is the strategy to do a yeast two-hybrid screen for the isolation of an unknown protein that interacts with a transcription factor of your interest?
22. What information can in situ hybridization provide? How does it compare to the promoter::reporter system?
23. How can you determine that a subcellular localization motif is located in the C-terminus instead of the N-terminus of a protein?

**Phytochemistry**
24. Draw the structure of isopentenyl diphosphate (IPP), and give an example of a class of compounds made from this building block.
25. What is a key regulatory enzyme in terpenoid production that involves a two-step reduction of a thioester group to a primary alcohol, and provides an essentially irreversible and rate-limiting transformation?
26. Biosynthetically, what is the basic building block for the majority of alkaloids?
27. Draw the basic structure of a flavan-3-ol, such as catechin.
28. What are phytoalexins?
29. What is the mechanism of action of acetogenins?
30. What class of compound is podophyllotoxin, and what biological activity does it have?
31. What is a phytoestrogen?
32. Name a class of toxic diterpene esters found in many species of Euphorbia.
33. What is a teratogen, and give an example of one found in plants.
34. Name two plant pigments, one water-soluble and one fat-soluble.
35. What are iridoids, and what biological activity has been found in this class of compound?
36. What is the mechanism of action of the anticancer compound camptothecin?
37. Name two plant families rich in cardioactive glycosides.
38. What class of alkaloids is found in *Atropa* species?

**Biostatistics and Ecology**
39. In plant ecology, what are “Importance Values” and how are they used?
40. This native of eastern Asia is perhaps the most common weedy tree of New York City. It has huge, pinnately compound alternate leaves with secretory glands that are clearly visible on the abaxial tips of the proximal lobes of leaflets. The leaves are deployed later in the Spring than those of our native tree species; and this may be partly responsible for its habitat restriction to forest edges. The seeds are wind-dispersed. A fast growing drought-resistant tree with soft wood, it germinates and thrives in disturbed urban environments where it appears immune to pests and pollution. Widely distributed across the world’s temperate zones, this invasive species is ________________.
41. In plant ecology, what’s the difference between a Collector’s Curve and a Species Area Curve?
42. In the 1930s and 1940s ___________, ___________, and ____________ were among the major scientists who crafted our Modern Theory of Evolution.
43. State the biological species concept. To whom is it attributed?
44. List several different methods by which the frequencies in a 2x2 contingency table may be analyzed.
45. What is the difference between parametric and nonparametric statistical methods?
46. Provide very specific reasons why a scientist might elect to pass a curve through a scatterplot using splines rather than by using some nonlinear least-squares regression model.
47. List some ways a researcher may increase “statistical power.”
48. What are “multiple comparisons” in anova?
49. What is the difference between the bootstrap and approximate randomization as statistical methods?
50. Within the context of building a model simulating some biological process, random sampling from theoretical probability distributions is called ________________.
SESSION 2: Basic Plant Biology. Answer these 50 questions. Two points credit each.

Basic Botany
51. Diagram a perfect flower with a hypanthium and label the parts.
52. What is the morphological difference between a root and a stem?
53. Diagram a typical moss life-cycle showing the alternation of generations. Please use the following terms: sporophyte, gametophyte, meiosis, zygote, fertilization, diploid (2n), haploid (n), sperm, egg.
54. What do stomata do?
55. When did the first flowering plants arise in the fossil record?
56. Name three different groups of plants with strobili.
57. What is a megaspore? What is a microphyll?
58. From where does endosperm come?
59. Name and describe 5 different ways seeds are dispersed.
60. What is circinate vernation?
61. How can you determine if a species is apomictic?
62. Why do flowers have color?
63. Name two ways that plants keep from selfing.
64. Why do many ferns have such large chromosome counts?

Very briefly define the following terms:
65. Sieve tube element
66. Perennial species
67. Tracheary element
68. Plasmodesmata
69. Apoplast
70. Primary xylem.
71. Secondary xylem
72. Adventitious roots
73. Plumule.

Systematics
74. What is an ad hoc hypothesis? Why should we seek to minimize ad hoc hypotheses in science?
75. What is the difference between nomenclature and taxonomy?
76. What is the approximate age of the earth? What is the approximate age of land plants?
77. Provide a well formatted couplet of a dichotomous key that accurately distinguishes two species of plants (include at least two distinguishing features).
78. What does the ensemble consistency index (C.I.) of a cladogram measure?
79. What are the different explanations for the occurrence of polytomies on consensus trees?
80. You conduct a cladistic analysis on a data matrix and find 15 equally parsimonious trees that are 120 steps long. You then find that the strict consensus of all 15 equally parsimonious trees is 145 steps long. How do you explain this length difference?
81. How can a chloroplast DNA phylogeny (gene tree) be used to discover hybridization among lineages?
82. What are the basic tenets of vicariance biogeography?
83. What is the phylogenetic relationship between monocots and dicots?
84. Name one of the most important biogeographers of the last 200 years.
85. What is the difference between a new species ("sp. nov.") and a new combination ("comb. nov.")?
86. What is a type specimen? What is the difference between a holotype and an isotype?
87. When you eat a mushroom, how many nuclear states are you consuming and what are the descriptive terms for these states?
88. What is rbcL? Why do most phylogenetic analyses of rbcL data lack parasitic plants?

**Ethnobotany/ Economic Botany**
89. Name two plants related to broccoli and also used as vegetables?
90. What kind of fruit is a tomato and from what part of the world did it originate?
91. Name two economically important crops that are derived from the grass family.
92. What is the difference between a cashew and a cashew apple?
93. Name two plant families known for their hallucinogenic properties.
94. Why are many legumes able to grow in relatively poor soils?
95. Name two fruits related to the tomato.
96. Among the world’s most important building material is wood. Botanically speaking what is wood?
97. Name two economically important products derived from coconuts.
98. What is kava?
99. In what area of the world are bananas native and why are native bananas not cultivated for food?
100. What kind of fruit is a pineapple?
SESSION 3: Essay questions. Answer any two questions (50 points each). Do not neglect the workers or the literature. Remember that the topics must be significantly different from your essay topic for session 4.

1. Recently, several saline-desert plants in the genera *Bienertia* and *Borszczowia* (Chenopodiaceae), and others, have been found to display the C4 mode of carbon fixation in single photosynthetic cells. These plants do not have Kranz anatomy. Discuss how it is possible to accommodate the C3 and C4-cycle enzymes in the same cell and the evolutionary advantages of single cell C4 fixation.

2. One of the current debates in systematics concerns the analysis of data that are derived from separate sources (e.g., molecules vs. morphology). Some people suggest that such data should be combined into one matrix and analyzed simultaneously, whereas others advocate separate analyses and comparison of partitioned results using a consensus method (i.e., the taxonomic congruence approach). Summarize this debate and defend your position, whether it is simultaneous analysis, taxonomic congruence, or some combination of the two.

3. In an experiment that aimed to determine the possible function of a putative AAA-type ATPase in the plant hormone ABA signaling pathway, various concentrations of ABA were applied to the Arabidopsis wild-type (Ws) and the ROP10 small GTPase loss-of-function mutant (*rop10-1*). The relative mRNA levels of the gene that encodes the ATPase were determined using quantitative real-time RT-PCR and the result is shown in the figure on the right. [The figure was adapted from Xin et al. (2005) *Plant Physiology*, 139: 1350-1365.]

   Please 1) interpret the data; 2) propose your hypothesis regarding the role of the putative AAA-type ATPase in ROP10-mediated ABA signaling; and 3) design a strategy to test your hypothesis.

4. Compare and contrast computationally intensive methods with traditional statistical methods.

5. Compound XY is a potent diterpene antioxidant from a culinary herb. Based on your knowledge of terpenoid biosynthesis, propose how this diterpene is biosynthesized. How would you test this hypothesis experimentally? What conditions would you alter experimentally in an attempt to increase the production of compound XY *in vitro or in vivo*?

6. The plant *Manihot esculenta* is of economic importance in tropical areas throughout much of the world. Where did this species originate? What parts of it are used? How is it cultivated? How are the products prepared? In other words discuss the economic botany of this plant.

7. Describe the characteristic organization of the vegetable shoot apex in flowering plants and the changes or differences that distinguish the floral shoot apex.
SESSION 4: (100 points)

Present a subject, problem, hypothesis, theory, or controversy you consider important to plant sciences. The essay should show relevance across the botanical subdisciplines. The essay should be both a review and a synthesis and demonstrate the level of scholarship, criticism, and independent thinking we require at the doctoral level. Your topic may be a large or a small one; broad or highly specialized; and you must communicate how the chosen topic is relevant to a major concept. We wish to measure the ability to understand and to synthesize information and ideas from more than one discipline of biology. Be sure to include something about the researchers and the literature. The essay must be significantly different from your responses to the questions of Session III. Finally, an essay based largely on the published work or grant proposals of faculty staff members or scientists at other institutions is not acceptable.