

**City University of New York Graduate School  
PhD Program in Biology–Plant Sciences First Examination 2007**

**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 does the presence of proteins in plasmodesmata suggest about their function?
2. What is the role of aquaporins in the movement of water across a largely hydrophobic plasma membrane?
3. Describe the casparian strip and its function. What is the most important substance in the casparian strip, from the point of view of its function?
4. What is the difference between a macronutrient and a micronutrient? Why is it difficult to supply iron in nutrient solutions and what is the best way to overcome this difficulty?
5. Briefly describe the differences between water transport via the apoplast and the symplastic/membrane pathways.
6. What is an action spectrum? What is the relationship between the action spectrum for photosynthesis and the absorption spectrum of chlorophyll?
7. Photorespiration is generally considered to be a wasteful process that decreases the yield of C3 plants. Briefly describe the phenomenon of photorespiration and indicate what organelles are involved. Why is it that C4 plants do not show photorespiration?
8. What is the "quiescent center" and where is it located? What is known about the function of the quiescent center?
9. Define the terms "senescence," "programmed cell death," and "apoptosis." Is senescence synonymous with "necrosis" (death)? Explain your answer.
10. Is the photoconversion of phytochrome from one form to another ever 100%? Explain your answer.
11. Describe the acid growth hypothesis of auxin action and the evidence that supports it.
12. Evaluate the following statement: "The level of abscisic acid in plant tissues remains constant under a variety of environmental conditions." True or false? Explain.
13. Discuss the structure and function of cereal aleurone layers. What role does gibberellin play in aleurone physiology?

**Plant Molecular Biology/ Genetics**

14. What is the molecular basis of dominance and recessiveness?
15. Is it possible that a gene has more than two alleles? Please briefly explain why.
16. Describe the difference between forward genetics and reverse genetics.
17. Which approach, gain-of-function or loss-of-function, can provide more convincing evidence regarding the function of a gene or gene product? Why?
18. If two recessive mutants, one early flowering and the other late flowering, were crossed, and the F1 showed an intermediate flowering phenotype, how would you explain the function of these two genes?
19. What is the advantage of transient expression in analysis of a transgene?
20. What is the potential weakness of the promoter:reporter system?
21. If reverse transcription has been performed using the RNA sample that might be contaminated by genomic DNA, what is the best PCR strategy to accurately analyze the transcript level for an intron-containing gene?

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22. If the sequences for the functionally conserved kinase genes are only available in *Arabidopsis* and rice genomes, how can you clone its ortholog in barley?
23. How can you determine that an N-terminal domain of a protein is necessary and sufficient for its nuclear localization?
24. An *Arabidopsis* mutant that decreased nitric oxide biosynthesis by 90% was isolated, but the wild-type gene product purified from *E. coli* did not possess any enzymatic activity by several assays. What is the most likely explanation?

**Phytochemistry**

25. From what biosynthetic pathway are acetogenins produced?
26. What class of compound is digoxin, and what is its mechanism of action?
27. What is the biosynthetic source of most alkaloids found in amphibians?
28. In what biosynthetic pathway is HMG-CoA reductase found, and why is it important for plants?
29. Name a phytoestrogen and its cellular target in humans.
30. What is allelopathy? Give an example in nature.
31. What is the amino acid building block for tropane alkaloids?
32. What class of compound is anagyrine, and what is its biological activity?
33. What are phorbol esters, and what family is a rich source of these compounds?
34. Name two plant families rich in cardioactive glycosides.
35. Why are pyrrolizidine alkaloids toxic?
36. Name two plant pigments, one water-soluble and one fat-soluble.
37. What class of compound is sennoside A? Where is this compound found, and what is its biological activity?
38. Define ethonobotany, and give an example of how it has been used to assist drug discovery.

**Biostatistics and Ecology**

39. What variables are measured in the assessment of ecological dominance for a woody plant species in a community?
40. Arguably, the most widely distributed native species of tree in our biome is \_\_\_\_\_.
41. As one might encounter these two terms in a regional flora, list the differences between “naturalized” and “invasive” as descriptors of species.
42. Identify the famous ecologist who was successful in championing the concept of the ecosystem as central to the discipline of ecology.
43. Generally speaking, \_\_\_\_\_ is the limiting chemical element in terrestrial ecosystems while \_\_\_\_\_ is the limiting chemical element in freshwater ecosystems.
44. The Nile Perch, when introduced into Africa’s Lake Victoria, became an invasive species and the aquatic food web was altered. Is this an example of bottom-up regulation or of top-down regulation of food web dynamics? Explain.
45. How does regression analysis differ from correlation analysis?
46. Provide advice on statistical procedures appropriate for small sample sizes.
47. What is “interaction” in factorial anova and how is it used in the interpretation of an experiment?
48. Relative to a research project, describe the utility of prospective power analysis.
49. Following one-way anova, list the trade-offs involved in deciding whether to perform orthogonal comparisons versus Bonferroni comparisons.
50. Present Bradley Efron’s Percentile Method for obtaining bootstrap confidence intervals.

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**SESSION 2: Basic Plant Biology.** Answer these 50 questions. Two points credit each.

**Basic Botany**

Very briefly define the following terms:

51. nucellus
  52. vascular cambium
  53. secondary growth
  54. hypotocyl
  55. pericarp
  56. sieve tube
  57. parenchyma
  58. endodermis
  59. stipule
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60. Describe the life cycle of a biennial plant.
  61. In a plant life cycle, the product of meiosis is a \_\_\_\_\_.
  62. Describe double fertilization and its products.
  63. What is an ovule? What is a seed?
  64. Define monoecy and dioecy.
  65. What are archeogonia and antheridia, and in which groups of plants are they found?
  66. Describe a typical female gametophyte of angiosperms, and explain the functions of the various cells/nuclei.
  67. In terms of plant reproduction, what is pollen? How is it an “improvement” over reproduction in species that lack pollen?
  68. What are two ways in which alternation of generations in ferns differs from mosses?
  69. What are two ways in which alternation of generations in gymnosperms differs from ferns?
  70. Describe fibrous and tap roots, and explain the adaptive advantages of each.
  71. How does conifer wood differ from angiosperm wood?
  72. What is a meristem? Name or describe three different angiosperm meristems.
  73. What is an abscission zone?

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**Systematics**

74. What is the phylogenetic relationship between gymnosperms and angiosperms?
75. Name five distinctive features of angiosperms.
76. Provide a well-formatted couplet of a dichotomous key that accurately distinguishes two plants (include at least two distinguishing features).
77. Briefly characterize the parsimony criterion as employed in phylogenetic analysis.
78. Approximately when did angiosperms first appear in the fossil record?
79. What are the different explanations for the occurrence of polytomies on consensus trees?
80. What is a type specimen? What is the difference between a holotype and a syntype?
81. What is the difference between heterotypic and homotypic synonyms?
82. Draw a cladogram that shows the relationships among the following terminal taxa: prokaryotes, mosses, red algae, green algae, angiosperms, ferns, gymnosperms. Root this cladogram with the prokaryotes.
83. What do fossils tell us about the age of taxa?
84. Briefly describe the difference between orthologous and paralogous genes.
85. What is a gene tree? Provide three reasons why gene trees may differ from species trees.
86. Briefly describe three different ways in which gaps can be coded for in a phylogenetic analysis of sequence data.
87. Briefly characterize the contributions of the following:
  - Carolus Linnaeus:
  - Arthur Cronquist:
  - Alfred Wegener:
  - Alfred Russell Wallace:

**Ethnobotany/ Economic Botany**

88. Name two plants in the same family as the eggplant and also economically important because their fruits are consumed by humans.
89. What kind of fruit is the fruit of the family Poaceae? Name a species of this family that is economically important and comes from the New World.
90. Name two economically important crops that are derived from the citrus family.
91. To what family does celery belong and what part of the plant is eaten?
92. What part of the plant is harvested to make cocaine and to what family does this plant belong?
93. Name one hallucinogenic fungus and one hallucinogenic Solanaceae.
94. Describe the difference in the way a coconut palm and a pine tree grow.
95. Name two economically important products derived from the xylem of trees
96. What is ayahuasca and where did it originate?
97. Name at least one plant explorer responsible for the introduction of plants from one to another part of the world.
98. In what area of the world are bananas native and why are native bananas not cultivated for food?
99. What two spices are derived from *Myristica fragrans*?
100. Name two plants that have been introduced from the New World into the Old World.

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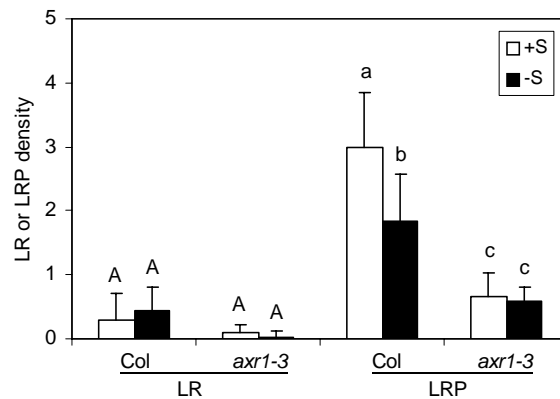
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**SESSION 3: Essay questions.** Answer any two questions (50 points each). Do not neglect the workers or the literature. Remember that the topics must be significantly different from your essay topic for session 4.

1. In a recent study (Kim et al. 2006), cells from the leaves of *Nicotiana benthamiana* were found to display programmed cell death (PCD) morphological markers such as nuclear condensation and DNA fragmented to sizes equal to and multiples of 180 nucleotides. Biochemical markers for PCD were tested; among them, mitochondrial cytochrome c released to the cytoplasm and caspase-3– and caspase-9–like activities. In additional experiments, the authors demonstrated that plants overexpressing *Arabidopsis* hexokinases 1 and 2 had enhanced resistance to chemically-induced PCD.
  - a) Do these cells (without hexokinase overexpression) show symptoms of apoptosis? Explain your answer.
  - b) From the hexokinase results in this plant, what general metabolic pathway(s) may be linked with PCD? Explain your answer.
  - c) How would you demonstrate caspase-like activity in a leaf extract?
2. Describe two theories of the origin of angiosperms from different groups of gymnosperms based on fossil evidence. What features of these plant groups form the basis for these theories? How does recent molecular evidence regarding gymnosperm phylogeny affect these theories?
3. Compare and contrast these two classes of statistical methods: randomization and bootstrap. Include in your answer, a consideration of the algorithms, assumptions, sample size, power, limitations and advantages of each method.
4. Describe seven of the most important morphological innovations in the evolution of land plants. What is the adaptive significance of these innovations? What groups do these innovations characterize?
5. Diterpenes have been found to be important medicines, but also some are extremely toxic. Discuss both toxic and beneficial diterpenes. Use at least two examples of toxic and two examples of beneficial diterpenoids in your essay.
6. Discuss the origin of chocolate. From where did it originate, from what part of the plant is it derived, and how is a candy bar produced from the chocolate plant?

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7. In an experiment that aimed to determine involvement of the plant hormone auxin in signaling the sulphate (S) nutrient deficiency response, an auxin resistant *Arabidopsis* mutant *axr1-3* was used for study. Wild-type (Col) and *axr1-3* plants were treated by S deficiency (-S), and as a comparative control, with S sufficiency (+S). The average densities for both emerged lateral roots (LR) and lateral root primordia (LRP) were shown in the following figure (adapted from Dan et al., 2006). Different letters (uppercase letters for LR, and lowercase letters for LRP) above the column indicate a statistically significant difference.



Please 1) interpret the data, 2) draw a conclusion regarding the role of AXR1-mediated auxin signaling in the response to S nutrient deficiency, and 3) propose a future research direction.

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**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.