


**City University of New York Graduate School  
PhD Program in Biology–Plant Sciences First Examination 2004**

**SESSION 1: Basic Plant Biology.**

Answer these 50 questions. Two points credit each. --PLEASE USE ANSWER SHEET.

**Plant Physiology**

1. Briefly describe one structural role and one metabolic role of  $\text{Ca}^{2+}$  in higher plants.
2. Propose an evolutionary explanation for the existence of a higher number of aquaporin genes in *Arabidopsis* with respect to humans and other animals.
3. Briefly describe the casparian strip and its function. From the point of view of function, what is the most important substance in the casparian strip?
4. (a) Define proton motive force (pmf). (b) According to Peter Mitchell's (chemiosmotic) theory, how does the pmf originate across the inner membrane of the mitochondrion and the thylakoid of the chloroplast?
-  5. What is an action spectrum? What is the relationship between the action spectrum for photosynthesis and the absorption spectrum of chlorophylls?
6. How are the major pigments and proteins involved in photosynthesis organized in the thylakoid membranes?
7. If cyt f, at the cyt b6f complex in the thylakoid membranes, has an  $E_m$  of 0.5 mV and plastocyanin's  $E_m$  is 0.48 mV. Based on these  $E_m$  values, one can predict that cyt f is the electron donor and plastocyanin is the acceptor. True or false? Explain.
8. What is the mechanism of action of the herbicide dichlorophenylurea (DCMU)? [Hint: it acts at the level of the quinone acceptors of photosystem II.]
9. The term "dark reactions" was used for many years to describe the reactions for incorporating  $\text{CO}_2$  in photosynthesis. Why was this term considered appropriate at the time and why is it considered inappropriate now?
10. Which are the three stages of the Calvin cycle? What are the biochemical outcomes at each stage?
11. What is photorespiration? How is the glyoxisome involved in photorespiration?
12. What is a bioassay and how did bioassays lead to the discovery of auxin?
13. What is the biochemical nature of abscisic acid (ABA)? In what organelle does ABA biosynthesis take place?
14. Which plant diseases are caused by cytokinin overproduction? What are the major symptoms of these diseases? [Hint: The causal agents can be bacterial or fungal.]
15. Why would a maize plant with a defect in the biosynthesis of abscisic acid biosynthesis be a viviparous mutant?

**City University of New York Graduate School**  
**PhD Program in Biology–Plant Sciences First Examination 2004**

**Ethnobotany/ Economic Botany**

16. Paracelsus proposed the “Doctrine of Signatures” to explain the uses of plants. What was the basis for this proposal?
17. Define the following terms:
  - a. Horticulture
  - b. Agriculture
18. According to recent archaeological evidence, what area is denominated the earliest Agricultural Region?
19. Who proposed the Eight Centers of Domestication?
20. How do plants achieve asexual propagation?
21. Connect the origin of the following fruit crops.

A. Olives	_____	1. South East Asia
B. Avocado	_____	2. China
C. Oranges	_____	3. Mexico
D. Coconut	_____	4. Mediterranean Region
22. Soybean (*Glycine max*) is considered the most important legume crop in the world. Name some of the products obtained from this legume.
23. Why is "crop rotation" a common agricultural practice?
24. Define and cite examples for the following structures:  
Rhizome  
Tuber
25. Sugar is obtained mainly from sugar cane (*Saccharum officinarum*). What other crop is used as a substitute?
26. “Blight” in potatoes is caused by which pathogen?
27. Coffee, chocolate and tea are the most commercialized stimulant beverages. Indicate their centers of origin.
28. Match the grass with the correct alcoholic product.

A. barley	_____	1. Dutch gin
B. rice	_____	2. chicha
C. corn	_____	3. whiskey
D. rye	_____	4. saké
29. What crop is considered the major contribution of the New World to the Old World?
30. Cite four plant sources for commercial oil.

**Plant Molecular Biology/ Genetics**

31. Who first discovered transposable elements and in what organism?
32. What is GenBank? Give an example of how and why you would use it.
33. What organism is used for transfer of DNA into plants?
34. What experiment would you carry out to determine whether a gene is expressed in only anthers and not in roots?
35. What is the function of a transit peptide?
36. \_\_\_\_\_ are small circular DNAs capable of independent replication in bacterial cells.
37. A \_\_\_\_\_ consists of a collection of bacteriophages containing inserted DNA sequences that are representative of all of the expressed genes in a given tissue from another organism.
38. Describe one experiment, including controls, to test for the presence of a transgene in a maize plant.
39. Give an example of a molecular marker and explain how it may be used.
40. Describe the general structure of the circular chloroplast genome.

**City University of New York Graduate School  
PhD Program in Biology–Plant Sciences First Examination 2004**

**Phytochemistry**

41. Fatty acid synthesis occurs in what plant organelle?
42. Draw an isoprenoid unit, and explain the “isoprene rule.”
43. What is the key regulatory enzyme in flavonoid biosynthesis in which phenylalanine is a substrate?
44. What is methyl jasmonate most commonly used for in plants?
45. Draw the basic structure of a flavonoid, and circle the parts of the molecule made through the acetate and mevalonate pathways.
46. What is a chemotaxonomy?
47. What is the mechanism of action of cardioactive glycosides?
48. What is a phorbol ester?
49. What class of natural product does etoposide belong to, and how is it used?
50. What phototoxic compounds are found commonly in Umbelliferae and Rutaceae?

**City University of New York Graduate School**  
**PhD Program in Biology–Plant Sciences First Examination 2004**

**SESSION 2: Basic Plant Biology.**

Answer these 50 questions. Two points credit each. --PLEASE USE ANSWER SHEET.

**Phytochemistry**

51. Name two plant pigments, one water-soluble and one fat-soluble.
52. What bioactivity is associated with the anthrones from senna?
53. Name an anticancer compound that comes from *Catharanthus roseus*.
54. What is a phytoestrogen?
55. Name two polyphenolic antioxidants found in chocolate.

**Biostatistics and Ecology**

56. In plant ecology, how do Importance Values provide a measure of ecological dominance?
57. The terrestrial biome just North of the biome within which you are sitting, is the \_\_\_\_\_ biome; and just North of this biome lies the \_\_\_\_\_ biome.
58. It has been well documented by local botanists that in the New York City metropolitan area about \_\_\_\_\_% of our species of vascular plants are non-native.
59. In plant ecology, what's the difference between a Collector's Curve and a Species Area Curve?
60. In the 1930s and 1940s \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_ were among the major scientists who crafted our modern theory of evolution.
61. State the biological species concept.
62. Why does the distribution of many biological variables follow the normal distribution?
63. List several very different methods by which frequencies in a 2x2 contingency table may be analyzed.
64. What is a Bonferroni correction?
65. Provide the general formula used for calculating confidence intervals.
66. In the comparison of two samples, compare the Kolmogorov-Smirnov two-sample test with the t-test, in terms of ability to detect differences in location and in dispersion.
67. What is analysis of variance (ANOVA)?

**Morphology and Development**

68. What is the most characteristic cell type of the dermal tissue system?
69. What is the most characteristic cell type of the ground tissue system?
70. What cell type or types best characterize the provascular tissue system?
71. From what embryonic tissue system is collenchyma most likely to develop?
72. What is a complete flower?
73. From what embryonic tissue system is a trichome most likely to develop?
74. What stelar type is most characteristic of dicots?
75. What stelar type is most characteristic of monocots?
76. From what does an embryo develop?
77. What distinguishes the leaf venation patterns of monocots and dicots?
78. Give an example of an aggregate fruit.
79. What does an ovule correspond to in non seed plants?
80. What is meant by anemophily?
81. What color is most associated with bird pollinated flowers?
82. What color is most associated with moth pollinated flowers?

**City University of New York Graduate School  
PhD Program in Biology–Plant Sciences First Examination 2004**

**Systematics/Basic Botany**

83. Define monophyly? Give an example of a monophyletic group.
84. Define synapomorphy. Give an example of a synapomorphy. What is the difference between apomorphy and plesiomorphy?
85. What does the length of a cladogram represent?
86. What is the difference between character state order and character state polarity?
87. Define hierarchy. Provide an example of an hierarchy.
88. Diagram a typical green-plant life cycle showing alternation of generations. Use the following terms: sporophyte, gametophyte, meiosis, zygote, fertilization, diploid (2n), haploid (n), sperm, egg.
89. Provide three synapomorphies of the angiosperms.
90. In what sense are hypotheses tested in a phylogenetic analysis?
91. What is the difference between parietal and axile placentation?
92. Name three families of flowering plants that have an inferior ovary.
93. Name three families of flowering plants that have milky latex.
94. What are the four whorls of a typical bisexual flower?
95. When did flowering plants appear in the fossil record?
96. What is the difference between a multiple fruit and an aggregate fruit?
97. Provide a single, well-formatted couplet of a dichotomous key that accurately distinguishes two plants (include at least two distinguishing features).
98. What is the difference between a fruit and a seed?
99. What is the difference between a rooted and an unrooted tree?
100. What is the difference between a stipule and a bract?

**City University of New York Graduate School**  
**PhD Program in Biology–Plant Sciences First Examination 2004**

**SESSION 3: Essay questions (10 questions).**

Answer any two questions (100 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. --PLEASE USE ANSWER SHEET.

1. Review the causal mechanisms which may account for the geographical variation we see in terrestrial plant species diversity.
2. Compare and contrast computationally intensive methods with traditional methods in biostatistics.
3. You are given a one kilobase fragment of DNA from *Arabidopsis* for which transcription is light regulated. Describe experiments with controls to identify and test what portion of the gene was responsible for this light regulation.
4. You wish to address a question that requires generating a phylogenetic hypothesis of the relationships among several related genera. How would you go about investigating these relationships? Name the individual steps and the requirements for this analysis.
5. Describe ten 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?
6. Compare and contrast roots and shoots of soil-growing, herbaceous flowering plants with respect to apical organization, lateral organ initiation, the cross sectional anatomy in the mature regions. Describe examples in which the distinctions between roots and shoots are not “typical.”
7. Discuss as fully as you can, the reasons for considering the primary vegetative body of flowering plants to be a unitary structure rather than a composite of separate organs such as roots, stems and leaves.
8. Discuss current hypotheses concerning the origin and early evolution of flowering plants.
9. Describe the range in form and structure of the male and female gametophytes of flowering plants and discuss the use of this information in determining possible evolutionary relationships.
10. Plants often produce hundreds of secondary metabolites, and many of these compounds tend to be closely related structural analogues. This contrasts to primary metabolites, such as sugars and amino acids, where far fewer analogues of these compounds are produced. What evolutionary advantages are there for plants to produce such a large number of secondary metabolites?

**City University of New York Graduate School  
PhD Program in Biology–Plant Sciences First Examination 2004**

**SESSION 4: (100 points) PLEASE USE ANSWER SHEET**

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.