

**City University of New York Graduate School
PhD Program in Biology–Plant Sciences First Examination Fall 2001**

SESSION 1: Basic Botany. Answer these 50 questions. Two points credit each. --PLEASE USE ANSWER SHEET.

Plant Physiology

1. Describe the process that drives transpiration in plants in terms of water potential gradients.
2. What is the difference between transport via symplast versus transport via apoplast?
3. What are the roles of nitrogen in plants?
4. What are the roles of K^+ in plants?
5. Mention at least four factors that influence stomatal aperture.
6. What are the roles of carotenoids in the photosynthetic systems?
7. Why is ATP and not NADPH + H^+ formed in cyclic photophosphorylation at PSI?
8. What three kinds of molecules are produced during the thylakoid-associated (“light-dependent”) reactions in photosynthesis?
9. What is the enzyme responsible for carbon dioxide fixation in the Calvin cycle (C3)? (Please write both the acronym and the whole name of the enzyme.)
10. What enzyme is responsible for carbon dioxide assimilation in the mesophyll cells of C4 plants (e.g. sugarcane, corn)?
11. What is the role of Rubisco activase? Is Rubisco activase dependent or independent from light?
12. What is apical dominance? What phytohormone is responsible for this phenomenon?
13. What phytohormone would stimulate the production of hydrolases (e.g. amylase) in cereals and what hormone would cause the opposite effect?
14. A tomato plant root exudate contains detectable amounts of gibberellic acid. What can you conclude regarding the transport of gibberellic acid?
15. What plant growth regulator is responsible for seed dormancy?
16. What phytohormone would stimulate the production of hydrolases (e.g. amylase) in cereals? What hormone would cause the opposite effect?
17. What is the plant hormone mainly involved in fruit ripening?
18. Salicylic acid is a molecule recently described as a plant hormone; what is its main action in plants?
19. Lettuce seeds (*Lactuca sativa*) cv. Grand Rapids are known to germinate under red light. In an experiment in which seeds were treated with alternating flashes of red light and far-red light, the last flash applied was of red light. Would the seeds germinate or not?
20. What is a “long-day plant”? Is this term correct?

Ethnobotany

21. Name the spice that comes from the aril of the *Myristica fragrans* fruit.
22. What is the principal use of *Virola theiodora* among South American Native Americans?
23. What is the genus name of the plant from which hashish is derived?
24. *Cinchona officinalis* is the source of this drug used to combat malaria.
25. What is the continent of origin of the sweet potato?
26. A small cactus (*Lophophora williamsii*) from northern Mexico is the source of this hallucinogen.
27. What is the latex of *Hevea brasiliensis* used for?
28. *Papaver somniferum* is the source of what street drug?
29. Vinblastine and vincristine, derived from *Catharanthus roseus*, are used to treat what disease?
30. Name a tuberous plant domesticated in the Andean highlands.

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SESSION 1, continued....

Plant Molecular Biology/ Genetics

31. What is a “promoter” and how is it important for gene expression?
32. Barbara McClintock was awarded the Nobel Prize for her research on...
33. Describe the general structure of most chloroplast genomes.
34. When a cDNA is isolated, and its sequence compared to that of the corresponding genomic DNA, they are not always the same; the cDNA sequence may appear to have multiple gaps as compared to the genomic DNA counterpart. Why?
35. A _____ consists of a collection of bacteriophages containing inserted DNA sequences that are representative of all of the genes of a given organism.
36. You wish to isolate a specific nuclear gene for which the DNA sequence can be found in GenBank. What reaction components are needed to isolate this gene using the polymerase chain reaction (PCR)?
37. What type of information might be obtained from carrying out a “Northern Analysis” experiment?
38. Given a DNA sequence and access to a WEB browser on the Internet, how would you identify a possible function of the encoded protein?
39. What are transgenic plants?
40. What is a restriction fragment length polymorphism?

Phytochemistry

41. Name the key regulatory enzyme in terpenoid biosynthesis that is used as a target for certain cholesterol-lowering drugs.
42. What is chemotaxonomy?
43. What is allelopathy?
44. Name two plant pigments, one water-soluble and one fat-soluble.
45. What bioactivity is associated with the anthrones from senna?
46. What biosynthetic pathway is responsible for the production of acetogenins in plants?
47. Draw the basic structure of a flavonoid, and circle the parts of the molecule made through the acetate and mevalonate pathways.
48. Name the odiferous secondary product, used widely in the perfume industry, which is now recognized as a plant hormone.
49. How many isoprene units do sesquiterpenes contain?
50. Acetylenic compounds are common in what plant family?

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SESSION 2: Answer these 50 questions. Two points credit each. --PLEASE USE ANSWER SHEET.

Systematics/Basic Botany

51. What book provides the rules of botanical nomenclature?
52. What is a synapomorphy?
53. What is the scientific name of the plant family from which coffee is derived?
54. Name at least one way in which the Phylocode differs from the Linnean system.

Pollination and Dispersal Biology

55. What is the most likely dispersal agent of a plant with microsporous seeds produced in very large quantities?
56. What is the most likely dispersal agent of a plant with fruits that open to display a single seed surrounded by a bright red aril?
57. What is the most likely pollinator of plant species with flowers that 1) form a chamber with downward pointing hairs on day one 2) smells like rotting meat, and 3) relaxes the downward pointing hairs day two?
58. What is a plant called that opens its anthers after the stigma is no longer receptive?
59. What is a plant called that has male flowers on one tree and female flowers on another tree?

Identification of Plant families. (Questions 60-65). Name the plant family. -PLEASE USE ANSWER SHEET.

60. _____ Leaves simple, opposite, with interpetiolar stipules; flowers with gamopetalous corollas and inferior ovaries.
61. _____ Broken petioles and cut stems exude white latex; leaves opposite; flowers with gamopetalous corollas, the lobes of the corolla often contorted, the ovaries often, but not always, in two separate parts while the styles remain fused.
62. _____ Leaves alternate; trunk often exudes red sap when cut; flowers unisexual, the perianth uniseriate; seeds with red, often branched, arils.
63. _____ Leaves opposite, simple, with pellucid punctations; stipules absent; flowers with numerous stamens, the ovary inferior.
64. _____ Leaves alternate, pinnately or bipinnately compound; stipules present; flowers actinomorphic; fruit splits along two sides.
65. _____ Leaves alternate; stipules absent; cut stems and trunk exude milky sap; flowers with gamopetalous corolla, the stamens adnate to the corolla and alternate with the lobes of the corolla.

Biostatistics

66. What's the difference between the bootstrap and randomization as statistical methods?
67. When calculated on the same sample mean, which is wider, the 95% confidence interval or the 99% confidence interval?
68. If the mean of a sample is 100 and the standard deviation is 20, then the standard normal deviate of the value 90 is _____.
69. Provide a use for statistical power analysis that is very practical for scientific research.
70. List three items that are usually mandatory to report in a table of descriptive statistics appearing in a scientific journal.
71. In statistical procedures, what do P-values measure?
72. In your research you develop a novel measure (a statistic) you wish to report. You do so in a manuscript submitted to a journal. The reviewers ask you to evaluate the reliability of this novel statistic in your revision of the manuscript. How do you do this?
73. Briefly contrast the reasons behind the choice of reporting R-square values or reporting variance components in analysis of variance.
74. What's the difference between standard deviation and standard error?

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SESSION 2, continued....

Cell and Developmental Biology

Questions # 75-85: Very briefly define the following terms:

75. Adventitious roots.

76. Epigeous germination.

77. Plumule.

78. Funiculus.

79. Procambium.

80. Protoderm.

81. Seed coat

82. Ground meristem.

83. Endodermis.

84. Casparian strip.

85. Rhizosphere.

Cell and Developmental Biology

86. What “part” of a plant may be composed of two generations of sporophytic tissue and one generation of gametophytic tissues?

87. How do adventitious, secondary, and primary roots differ from one another with respect to their site of origin?

88. What is/are the most fundamental distinction(s) between the processes of differentiation and morphogenesis?

89. The plant body is composed of tissue systems, each with its characteristic tissues. What are the three most characteristic tissues of the “Ground Tissue System” in flowering plants?

90. The plant body is composed of tissue systems, each with its characteristic tissues. What are the three most characteristic tissues of the “Vascular Tissue System” in flowering plants?

91. Name the organelle(s) in which genetic information in the form of DNA is located.

92. What feature distinguishes transfer cells from other parenchyma cells?

93. Name all the meristems in flowering plants that give rise to primary tissues.

94. Describe the chemical constituents of microtubules and how these constituents make up the structure.

95. Describe the conditions under which prolamellar bodies form and the make-up of these bodies.

96. What is the form of chemical energy formed in conjunction with the electron transfer pathway in mitochondria?

97. List the sequence of events in the production of a protein which will function in a chloroplast.

98. Describe the organization of the nuclear envelope.

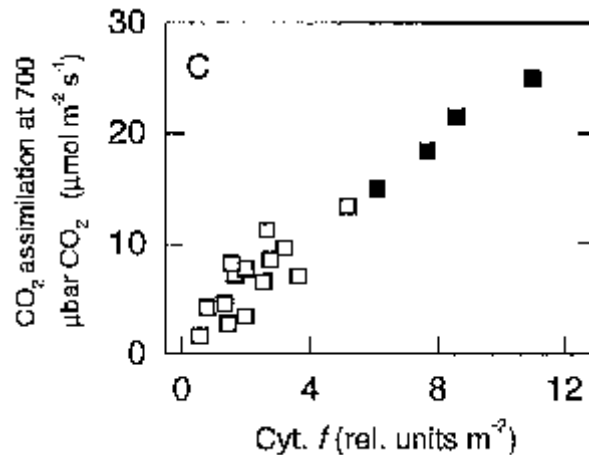
99. Thylakoids in chloroplasts are often/usually arranged in structures called?

100. Explain what occurs in the S stage of the cell cycle.

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SESSION 3: Essay questions. Answer any two questions. 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. The herbicide DMCU, or diuron (3-(3', 4'-dichlorophenyl)-1,1-dimethylurea), does not affect photosystem I but intercepts electrons near photosystem II, affecting the plastoquinone-binding protein. Design an experiment to measure the inhibitory effect of DMCU on electron transport in the thylakoid membranes. Remember to establish appropriate controls. How can you obtain intact chloroplasts? How does DCMU ultimately affect the biosynthesis of starch in weeds?
2. The figure below is adapted from Ruuska et al. (2000) *Plant Physiol.* 122:491-504.



The graph represents a _____ series of experiments in which carbon assimilation was measured in wild-type tobacco plants (dark squares) and transgenic tobacco plants with varying contents of Cyt *b/f* complex determined as relative units of cytochrome *f* (open squares).

- (a) From this graph, what is the effect of decreasing the amount of functional Cyt *b/f* complexes in the thylakoid?
- (b) What is the range of percentages of Cyt *b/f* observed in the transgenic plants? (Assume that 9 relative units/m² is 100%.)
- (c) Is this result expected from antisense *b/f* mutants? _____ Why?
- (d) How could a change in the amount of Cyt *b/f* (a thylakoid membrane complex) affect the rate of carbon dioxide assimilation in the stroma?

SESSION 3, continued....

3. Describe in detail the two current models for auxin-mediated cell wall expansion. What do they have in common? How do they differ from each other? What is the ultimate explanation for the expansion of the cellulosic cell wall?
4. Plant taxonomists are often required to change the names of plants. Why are these changes needed?
5. Discuss the relative merits of the Linnaean system of classification, the PhyloCode, and the BioCode.
6. What is special about the growth habits and physiological characteristics that have made grasses such important plants throughout human history? Name some of these important grasses and where they originated.
7. An intricate trophic food web was developed in Precolumbian times in central Mexico. What were the important plants involved and how did the ancient Mesoamericans generate such an efficient food procurement system in the absence of major sources of domesticated animal protein?
8. Explain how a plant leaf comes into thermal energy balance with its physical environment. Include in your answer a treatment of the influence of leaf form, leaf anatomy and leaf physiology and explain how heat transfer theory applies to a leaf.
9. Describe how a genetic map might be constructed on the basis of molecular markers, explain why this type of molecular map is usually more saturated with markers as compared to a standard genetic map, and what approaches might be used to correlate a molecular map with a genetic map.
10. Describe how you would genetically engineer a plant to obtain low expression levels of Bt toxin in stem tissue and not in any other part of the plant.
11. Characterize the “organelles” that make up the cytoskeleton and the endomembrane system and describe the roles each of these has in the processes of cell partitioning and cell elongation.
12. Describe the “primary processes” that account for the evolutionary changes in sporophytes from the primitive Rhyniophyte-type to those characteristic different phyla of extant land plants according to Zimmerman’s Telome Theory. Describe any alternative explanations for any of these changes that you have learned about.
13. Describe the biosynthesis of monoterpenoids. Give two examples of therapeutic monoterpenoids, and two examples of toxic monoterpenoids.

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SESSION 4—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 staff members is not acceptable.