

City University of New York Graduate School
PhD Program in Biology–Plant Sciences First Examination 2003

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

Plant Physiology

1. What is the difference between mineral macro and micronutrients? Cite five examples of each.
2. What are aquaporins?
3. Briefly describe two physiological roles of K⁺ in higher plants.
4. The equation $\Delta p = \Delta E - 59 \Delta \text{pH}$ represents the proton motive force, the free energy associated with the formation of an electrochemical proton gradient. What does the term ΔE represent?
5. What is an action spectrum? Give an example from a photosynthetic phenomenon.
6. The electron carriers in the photosynthetic membranes of oxygen-evolving organisms possess different midpoint redox potential (E_m) values. What is the definition of E_m ?
7. If cyt f, at the cyt b₆f complex, has an E_m of 0.5 mV and plastocyanin's E_m is 0.48 mV, which one is the electron acceptor?
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. It is estimated that ribulose-1,5-bis-phosphate carboxylase oxygenase (Rubisco) constitutes up to 50% of the total protein weight in a plant's leaves. Why is Rubisco such an abundant protein?
10. Which are the three stages of the Calvin cycle? What are the biochemical outcomes at each stage?
11. What is photorespiration? What organelles are involved?
12. Briefly describe the mechanism for polar transport of auxins.
13. Briefly describe two developmental or physiological roles of abscisic acid.
14. Briefly describe three developmental or physiological roles of cytokinins in plants.
15. Why would a maize plant with a defect in the biosynthesis of abscisic acid biosynthesis be a viviparous mutant?

Ethnobotany/ Economic Botany

16. Chocolate is derived from what part of the plant?
17. Potatoes are native to what part of the world?
18. Why do bananas lack seeds?
19. What database would you refer to find out what is known about the chemical composition of a plant?
20. In the past, life preservers were filled with fibers from what plant?
21. Name a plant native to North America that has become domesticated.
22. Coffee is native to what part of the world?
23. From what plant family are cauliflower, Brussels sprouts, and broccoli derived?
24. What was the nationality of the person who collected the rubber seeds from the Amazon that served as the original source of the Southeast Asian rubber industry?
25. A stalk of celery is what part of the plant?

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Plant Molecular Biology/ Genetics

26. Barbara McClintock was awarded the Nobel Prize for her research on...
27. 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?
28. What experiment would you carry out to determine whether a gene is expressed in only anthers and not in roots?
29. What are transgenic plants?
30. Describe the general structure of most chloroplast genomes.
31. If you had a very small sample of plant tissue, and you wanted to isolate and sequence a gene, you could use _____ to amplify the gene of interest.
32. In order for a nuclear encoded protein to be targeted and imported into the chloroplast, the protein must usually have a.....
33. Given a DNA sequence and access to a WEB browser on the Internet, how would you identify a possible function of the encoded protein?
34. _____ are small circular DNAs capable of independent replication in bacterial cells.
35. What is a “promoter” and how is it important for gene expression?

Phytochemistry

36. How many isoprene units do triterpenes contain?
37. What is the “isoprene rule”?
38. Name the odiferous secondary product, used widely in the perfume industry, which is now recognized as a plant hormone.
39. Draw the basic structure of a flavonoid, and circle the parts of the molecule made through the acetate and mevalonate pathways.
40. Give an example of a plant that uses its natural products for allelopathy.
41. What is the mechanism of action of acetogenins?
42. What acetate-derived compounds are found uniquely in the Asteraceae?
43. Name an important alkaloid drug and its botanical source.
44. Define teratogen, and name a natural product teratogen.
45. Name two plant pigments, one water-soluble and one fat-soluble.
46. Name an anticancer compound that comes from *Taxus brevifolia*.
47. Name a subclass of flavonoids that have estrogen-like activity.
48. Name two polyphenolic antioxidants found in tea.
49. What class of primary metabolites are the biosynthetic precursors to most alkaloids?
50. Name a key regulatory enzyme in flavonoid biosynthesis.

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

Biostatistics and Ecology

51. The Bronx resides within the _____ biome.
52. It has been recently documented by local botanists that there are about ____ species of higher plants growing within a 50 mile radius of Columbus Circle in Manhattan. About what per cent of these are non-native species?
53. This native of eastern Asia is perhaps the most common, naturalized and weedy tree of New York City. It has huge, pinnately compound alternate leaves with large, swollen secretory glands that are clearly visible on the abaxial tips of the 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 species is _____.
54. In the 1930s and 1940s _____, _____, and _____ were among the major scientists who crafted our Modern Synthetic Theory of Evolution. (One of your answers must be a botanist.)
55. In statistical data analysis, _____ communicate uncertainty about sample statistics as estimators of population parameters.
56. What's the difference between the bootstrap and randomization as statistical methods?
57. What are "multiple comparisons" in anova?
58. Provide the general formula for calculating confidence intervals for any statistic.
59. Provide very specific reasons why a scientist would elect to pass a curve through a scatterplot using splines rather than by using nonlinear least-squares regression.
60. List two ways a researcher can increase statistical power.

Cell and Developmental Biology

Very briefly define the following terms:

61. Rachis.
62. Tendril.
63. Stolon.
64. Tuber.
65. Tunica-carpus.
66. Protosteles.
67. Siphonostele.
68. Haplostele.
69. Atactostele.
70. Plectostele.

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Cell and Developmental Biology

71. Embryogeny proceeds to different extents in different species. Name all the portions of a monocot embryo that might be considered extensively developed such as those of cereal grains.
72. Parenchyma often forms a continuous system throughout the primary plant body; a fact that may be obscured by the different names given the regions of the plant through which it forms the continuum. What are the names of these regions in the roots, stems, and leaves?
73. What feature distinguishes collenchyma from parenchyma cells?
74. Describe the formation of lysosomes and the cytochemical method of identification.
75. Describe how chromosomes are organized.
76. Explain the function of microbodies (peroxisomes).
77. Explain how new centrioles are formed in dividing cells.
78. Describe the events occurring in a cell producing new cell wall material.
79. Draw a plasmodesmata in cross section and indicate the diameter.
80. Describe the structure of a mitochondrion.
81. What function(s) does (do) the cell wall serve in plants?
82. -83. Name four types of plastids and their most characteristic functions.

Systematics/Basic Botany

84. What are the three parts of a complete scientific name?
85. Give an example of how a character differs from a character state.
86. A specimen upon which a scientific name is based is called a _____ specimen.
87. The most economically important family of monocots is the _____ (give Latinized name).
88. Name three types of leaf arrangement on a stem.
89. What is the ending used in the Latinized names of families? Orders?
90. Give three characteristics of monocots.
91. A collection of dried, pressed, labeled plants is called a _____?
92. List three characteristics that distinguish green plants from animals.
93. Place these taxa in hierarchical order from highest to lowest rank: family, class, variety, species, order.
94. Draw a 2-pinnate leaf and label the petiole.
95. A typical dicot leaf consists of three parts. Name them.
96. A plant with four sets of chromosomes is called a _____.
97. In a cladistic analysis, relationships are based on characters called _____.
98. A species that has staminate and carpellate flowers produced on separate plants is called _____.
99. Hornworts, liverworts, and mosses are collectively referred to as _____.
100. In flowering plants, branching occurs from the _____.

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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. --PLEASE USE ANSWER SHEET.

1. What is meant by "correlative control" in plant development? Discuss the role that correlative inhibition of cell division and directional enlargement play in plant morphogenesis as well as the physiological/chemical factors that control these processes.
2. Discuss the requirements of the *International Code of Botanical Nomenclature* for naming new species. Are these requirements necessary?
3. You have a one kilobase DNA fragment. Describe what you can do to determine whether it codes for a gene and if so, what might be the function of the gene product.
4. Discuss and explain the endosymbiotic and autogenous theories for the origin of eukaryotes.
5. Describe the components of the cytoskeleton of the plant cell and how they may relate to developmental and physiological processes.
6. You want to study the role of auxins in the phototropism of sunflower *Helianthus annuus* plants growing in the field (assume there is no nocturnal urban glow!). Your initial observations are that at sunset the flower head is facing west but before sunrise the flower head has moved back and faces east. You decide to measure auxin levels both in the side of the flower head stem that was facing east at sunset and in the side that was facing west.
 - (a) Postulate a hypothesis to explain the role of auxins in the remarkable phototropism of the *Heliantus annuus* flower head.
 - (b) In which side do you expect the auxin levels to be higher at sunset?
 - (c) You decide to measure auxin levels throughout the night, in the flower stem areas that were facing west and east at sunset. At 3 A.M., you find that auxin levels are increasing in the side that was facing east at sunset. Is this what you might expect?
 - (d) Would your finding in (c) explain the eastward turning of the flower head at sunrise?
7. Compound XY is a potent diterpene antioxidant from a culinary herb. Based on your knowledge of terpenoid biosynthesis, propose how and where this diterpene is biosynthesized
8. Tropical rain forests are more diverse in species of plants and animals than any of the other ecosystems in the world. Discuss some of the theories that have been forwarded to explain this high diversity.
9. Explain how molecular information is used to resolve problems in plant systematics. Include a discussion of different molecular techniques and give specific examples of problems that have been resolved.
10. Describe in detail, how an individual plant leaf achieves thermal energy balance with its microclimate.
 - (a) Present the Gates leaf energy budget model either as an equation or by compelling verbal explanation; and identify the four independent variables and the two dependent variables.
 - (b) Explain how leaf size, leaf shape, leaf orientation and leaf optical properties influence thermal energy balance.
 - (c) Before the development of plant physiological ecology and biophysical ecology as fields of study, many botanists, even plant physiologists, viewed transpiration as a "necessary evil." How has this view changed?
 - (d) Finally, provide a biophysical answer to this question: "In the native flora of the deserts of New Mexico, why do we not find plants with leaves like those of the banana tree?"

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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.