

**City University of New York Graduate School
PhD Program in Biology–Plant Sciences First Examination 2002**

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

Plant Physiology

1. Briefly describe one method to measure water potential using a whole plant or plant parts.
2. What are the main roles of Ca^{2+} in plants?
3. How can water move up the xylem when a vessel element is cavitated (*i.e.*, contains a water vapor bubble instead of liquid water)?
4. In the chemiosmotic mechanism, it is proposed that the total energy available for photosynthesis, or **pmf** (proton-motive force, Δp), is composed of two terms, $\Delta p = \Delta E + 59 \Delta \text{pH}$. Briefly describe how ΔpH is produced during the thylakoid-associated reactions of photosynthesis.
5. Why is the term "dark reactions" inadequate to describe the carbon assimilation reactions in photosynthesis?
6. Rubisco is the acronym of the enzyme that catalyzes the main carbon fixation reaction in the Calvin cycle. What is the whole name of the enzyme? What are the substrates and the stable product?
7. What metabolic pathway is activated to salvage carbon that may be lost because of the oxygenase activity of Rubisco?
8. The Calvin cycle is partially light-dependent, as several enzymes are activated by the ferredoxin-thioredoxin (Fd-Td) system. Briefly describe the Fd-Td system (you may use diagrams).
9. A dimer of the 22-kDa auxin-binding protein 1 (ABP1) has been postulated to be an intracellular receptor for auxins. Briefly describe two ways in which ABP1 is involved in auxin signaling.
10. In what sites of a mature plant is gibberellic acid (GA) synthesized?
11. In what phase of the cell cycle does cytokinin induction of cell division occur?
12. What phytohormone would stimulate the production of hydrolases (*e.g.* amylase) in cereals?
13. Briefly describe three developmental or physiological effects of ethylene on plants.
14. Salicylic acid has been described as a plant hormone; what is its main action in plants?
15. Jasmonic acid (JA) is a molecule produced by some plants in response to wounding. What is the membrane-associated lipid precursor of JA?

Ethnobotany/ Economic Botany

16. What was the first plant domesticated in the Americas?
17. What was the most important grass domesticated in the Americas?
18. Name an important root crop native to the South American lowlands?
19. Where did the common bean (*Phaseolus vulgaris*) originate?
20. Approximately when did agriculture begin in the Americas?
21. Where did coffee originate?
22. What was the most economically important tree crop in ancient Mesoamerica?
23. What was the most important root crop to the Inca of the Andes?
24. Name a grass domesticated in the Near East.
25. Where did the bottle gourd (*Lagenaria siceraria*) originate?

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Plant Molecular Biology/ Genetics

26. The function of the promoter region of a gene is _____.
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. If you were interested in making a collection of DNA clones that represented all of the genes that were expressed in petals of a particular plant, you would _____.
29. How are restriction enzymes and DNA ligase used to combine DNA fragments?
30. What are transgenic plants?
31. Describe the general structure of most chloroplast genomes.
32. _____ are small circular DNAs capable of independent replication in bacterial cells.
33. What advantage in creation of genetic maps do molecular markers have over traditional phenotypic genetic markers?
34. What is cosuppression?
35. An enzyme using mRNA as a template to synthesize DNA is _____.

Phytochemistry

36. How many isoprene units do monoterpenes contain?
37. What is the “isoprene rule”?
38. Name the key regulatory enzyme in terpenoid biosynthesis that is used as a target for certain cholesterol-lowering drugs.
39. Name the odiferous secondary product, used widely in the perfume industry, which is now recognized as a plant hormone.
40. Draw the basic structure of a flavonoid, and circle the parts of the molecule made through the acetate and mevalonate pathways.
41. What is a chemotaxonomy?
42. What is the mechanism of action of acetogenins?
43. What acetate-derived compounds are found uniquely in the Asteraceae?
44. What is paclitaxel, and how is it used?
45. Name two plant pigments, one water-soluble and one fat-soluble.
46. What toxicity is associated with lupin alkaloids?
47. What bioactivity is associated with the anthrones from senna?
48. Name an anticancer compound that comes from *Catharanthus roseus*.
49. Name a subclass of flavonoids that have estrogen-like activity.
50. Name two polyphenolic antioxidants found in tea.

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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. What's the difference between the standard deviation of a sample and the standard error of the mean of the same sample?
52. List two ways a researcher can increase statistical power.
53. What are "multiple comparisons" in anova?
54. What is a "contingency table"?
55. Provide the general formula for calculating 95% confidence intervals for any statistic.
56. How do parametric descriptive statistics differ from nonparametric descriptive statistics?
57. What's the difference between the bootstrap and randomization as general statistical methods?
58. Why would a scientist elect to pass a curve through a scatterplot using splines rather than by using nonlinear regression?
59. What is a keystone species?
60. List three species of invasive, non-native trees that grow wild in New York City.
61. There are about _____ species of vascular plants growing wild, within a 50 mile radius of Columbus Circle in New York City.
62. List the scientific names of the dominant plant species of salt marshes in the vicinity of New York City.

Cell and Developmental Biology

Questions #63-72: Very briefly define the following terms:

63. Abscission.
64. Bulb.
65. Corm.
66. Central mother cells.
67. Xerophyte.
68. Mesophyte.
69. Hydrophyte.
70. Cambium.
71. Intercalary meristem.
72. Mesophyll.

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Cell and Developmental Biology

73. The life histories of plants are described as proceeding through an alternation of sporophytic and gametophytic generations. How many generations go into the composition of a seed?
74. Embryogeny proceeds to different extents in different species. Name all the portions of a dicot embryo that might be considered fully developed (e.g. that of a bean or pea).
75. Which sporangia in seed plants become enveloped in integuments, microsporangia or macrosporangia?
76. Name the meristems in flowering plants that give rise to secondary tissues.
77. Some seed-plant tissues are simple while others are complex. In the space provided next to the names of the following tissue types, specify with an “s” those which are simple and with a “c” those that are complex: collenchyma____, phloem____, xylem____, epidermis____, parenchyma____, sclerenchyma_____.
78. In addition to the nucleus and mitochondria, where also is DNA found in plant cells?
79. Describe the chemical make-up of microfilaments.
80. Describe the structure of a chromoplast.
81. What is the obvious structural difference in rough endoplasmic reticulum (RER) and smooth endoplasmic reticulum (SER)?
82. Draw a metaphase chromosome and label all parts.
83. Describe the organization of the nuclear envelope.
84. Briefly describe the different kinds of plastids and if they can be converted from one kind to another.
85. Name the stages in the cell cycle.

Systematics/Basic Botany

86. With what field of systematics is Willi Hennig's name associated?
87. Name two different species concepts.
88. Give one defining feature of angiosperms.
89. Which are two of the largest families of angiosperms?
90. Which term is used for plants with separate sexes?
91. Which three angiosperm families are most important for man?
92. Give three characters of monocotyledons.
93. What is the difference between a synapomorphy and an autapomorphy?
94. What is the difference between paraphyletic and polyphyletic groups?
95. Which is the most species-rich group: angiosperms, gymnosperms, fungi?
96. Place these taxa in hierarchical order, from lowest to highest rank: superfamily, genus, order, family, section.
97. What is the ending used in the latinized names of families? Orders?
98. In which regions of the world are there the largest remaining areas of lowland tropical rainforest?
99. Which chloroplast gene is commonly used in molecular systematics?
100. Name two terms for flowers with both androecium and gynoecium.

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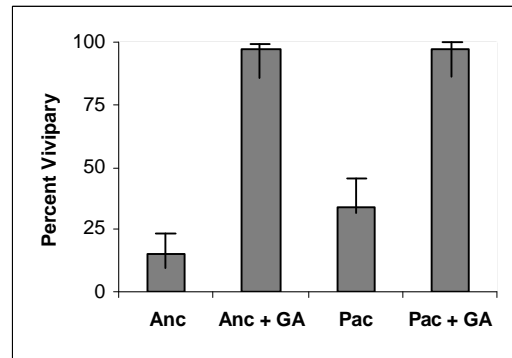
SESSION 3: Essay questions. Answer any two questions (50 points each). Do not neglect the workers or the literature. Remember that the topics must be significantly different from your essay topic for Session 4. -- PLEASE USE ANSWER SHEET.

1. You require to test a batch of barley (*Hordeum vulgare* L.) seeds for their responsiveness to gibberellic acid (GA). In the literature, you have found an article describing an assay for the GA-induced production of α -amylase. The technique is based on the formation of a colored complex amylose-I₂. [Hint: Some GA-induced pathways require small amounts of calcium].

a) Design an experiment to measure α -amylase activity. Establish the appropriate controls.

b) How would you test the effect of ABA (abscisic acid) on the GA-induced α -amylase production in the barley seeds?

2. The figure at right is adapted from White *et al.* (2000) Plant Physiol. **122**:1081-1088. The graph presents data from an experiment in which ears of maize viviparous mutants (*vp5*) were treated with two inhibitors of GA synthesis: ancymidol (**Anc**, 100 μ M) or paclobutrazol (**Pac**, 100 μ M), either alone (bars 1 and 3, respectively) or in combination with 100 μ M GA₃ (bars 2 and 4, respectively). The treatments were done 9 days after pollination (DAP). A value of 100% reflects the level of vivipary in the mutants without any treatment. These viviparous mutants are blocked in ABA synthesis.



a) From this graph, can you conclude that GA restores vivipary in the *vp5* mutant? Explain.

Because GA and ABA act antagonistically in many aspects of plant development, the authors hypothesized that, since there is no ABA produced in maize *vp5* mutants to counteract GA, GA triggers precocious germination.

b) Do the data shown on the graph confirm their hypothesis? Yes _____ No _____

c) Explain why.

d) Can you infer from these results that GA and ABA affect a common step in the processes leading to germination? Explain your answer.

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3. Discuss the domesticated food complex of the Ancient Mesoamericans. Where did it come from? What were the synergistic factors, both dietary and agronomic, that contributed to the success of this food complex?
4. Many authors have noted that the plant diversity found in Central America is a result of the merging of two major floristic kingdoms. Describe these two kingdoms and how/why did they merge? How are the representatives of these two floral kingdoms arrayed across the modern landscape?
5. Given availability of genes for starch biosynthesis, describe in detail how you would genetically engineer maize to obtain increased expression of starch only in endosperm tissue and not in other plant parts, given that the pathway is regulated primarily through transcriptional control of one rate limiting enzyme. Make sure to detail what would be required in terms of gene constructs, transformation methods, and selection/screening methods. Also describe potential problems and how these would be avoided.
6. You are given a 2 kb DNA fragment from Arabidopsis. Using bioinformatic and experimental approaches, describe how you would characterize the DNA in a one year period, to determine whether it codes for a protein, where that protein is expressed and what function it might possess.
7. Describe the use of the plant natural product, β -carotene, in cancer prevention. What have recent clinical trials found regarding its efficacy?
8. Describe the chemotaxonomic distribution, therapeutic activity, and mode of action of cardioactive glycosides.
9. Discuss quantitative forest inventory as an area of botanical research. Discuss theory, field methods, and data analysis.
10. Describe three ways in which localized suppression of growth can influence pattern development and pattern change during plant development from a spore or fertilized egg (zygote). Summarize the experimental evidence that implicates auxin, ethylene and arabinogalactan proteins in the regulation of time and place-dependent growth suppression.
11. Two of the driving forces in plant morphogenesis are directional cell proliferation and directional cell enlargement. Describe, as fully as possible, how the cytoskeleton and associated cellular components contribute to these two processes.
12. Compare the structure of plant cells as one would observe as you go from the outside (epidermis) of a plant stem to the interior (pith).
13. Describe the components of the cytoskeleton of the plant cell and how they may relate to developmental and physiological processes.
14. Outline how the theory and practice of systematics has changed in the years 1950 to 2000.
15. Would you expect morphological and molecular data from the same taxa, analyzed in the same way, to give the same results? Why?

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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 staff members is not acceptable.