CITY UNIVERSITY OF NEW YORK GRADUATE SCHOOL
Ph.D. PROGRAM IN BIOLOGY – 2010 PLANT SCIENCES FIRST EXAMINATION

SESSION I. ESSAY to submit before the morning session. (TOTAL 100 pts)
Instructions: Submit the Session I essay in hard copy and in electronic form as a PDF file. Do not put your name on either, use your student number for filename and for marking the hard copy. Make sure that in "properties" there is no notation of "author".

Present a subject, problem, hypothesis, theory, or controversy you consider important to plant sciences. **The essay must be hypothesis driven.** 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. The paper should have a title and begin with a **one paragraph abstract/summary which includes your hypothesis.** The paper should be paginated and written with 11 pt. Arial or equivalent font, one-inch margins, and a **maximum of five (5) pages of double spaced text** followed by a minimum of 15 (complete) literature citations provided in the format required by the journal, Plant Physiology (see: http://www.plantphysiol.org/misc/ifora.shtml). Following the literature citation section, provide the names (from faculty in the CUNY Biology PhD program) of two potential "reviewers" along with their areas of expertise which you feel make them appropriate to reviewers of your manuscript. *Note: an essay based largely on the published work or grant proposals of faculty staff members or scientists at other institutions is not acceptable. The essay must be your own idea and not the product of a collaborative effort. Faculty should not be consulted in development of your essay.*

SESSION II. MORNING (TOTAL 300 pts)
Instructions:
1-Basic Botany: Definitions and short answer botany questions (100 pts)
2- Write an essay in each of two subject areas (Taxonomy/systematics, Bioinformatics) (100 pts each essay, for a total of 200 pts). For each topic area, students must choose one of the two essay questions.

EXAM QUESTIONS

1. BASIC BOTANY, total 100 points

Basic Botany, definitions. Choose 10 questions. 5 points each.
Provide brief definitions of the following:

1. Endosperm
2. Middle lamella
3. Wood
4. Sporophyll
5. Meristem
6. Kranz anatomy
7. Allopolyploid
8. Phyllode
9. Anaphase
10. Apomixis
11. Stipule
12. Rhizobia
13. Multiple fruit
14. Apoplast
15. Embryo sac
16. Coenocyte
17. Compound leaf
18. Dioecious
19. Dikaryotic
20. Ribosome

Basic Botany, short answer. Choose 5 questions. 10 points each.
Briefly answer the following:

1. What is double fertilization in the plant life cycle? Which groups have this character?
2. How many different genomes are there in a typical diploid plant cell? What is the inheritance of each of these?
3. What is the endosymbiont hypothesis?
4. What is the general equation for photosynthesis?
5. What is the difference between microsporogenesis and microgametogenesis?
6. What are three floral features commonly associated with wind pollination?

7. What is the difference between spines, prickles, and thorns?
8. What is the difference between a parasite and a mycoheterotroph (mycotroph)?
9. What are the properties and functions of vessels in land plants?
10. Is the progeny of self fertilization genetically identical to the parent? Why or why not?

ESSAY QUESTIONS: SYSTEMATICS (choose one of two, 100pts):

1. For the paper by Barkman et al. (2007), answer the following questions. Your answers should be written in your own words, as complete sentences, and not as lists or fragments.

A. What is the primary question that the authors are attempting to address?
B. What is the reason for using mitochondrial genes for phylogeny reconstruction in this study?
C. What is horizontal gene transfer? Why would undetected horizontal gene transfer be a problem in a phylogenetic study?
D. Which taxa are endoparasitic? Based on the results, how many independent origins of endoparasitism are indicated? How does this contrast with previous assumptions on the origins of endoparasitism?
E. Summarize the evidence and argument in support of the horizontal transfer of mitochondrial *atp* I between parasites and hosts. How did the authors rule out contamination?
F. Suppose you were called upon to teach a course in Plant Taxonomy. Based on the results of this study, describe how would you organize information about parasitic plants? Would this information be presented in a single lecture or at different times through the semester? Why?

2. For the paper by Albert et al. (1992), answer the following questions. Your answers should be written in your own words, as complete sentences, and not as lists or fragments.

A. What is the primary goal of the study?
B. What was the source of data that the authors used to reconstruct phylogeny? Why did they use data from this source, rather than from morphology?
C. Why are the authors careful to stipulate that their results represent gene trees?
D. Why is it important to examine the evolution of different kinds of insect-trapping mechanisms?
E. Based on the results of this study, provide an example of structural convergence from separate ancestry. Provide an example of structural divergence from common ancestry.
F. Suppose you were called upon to teach a course in Plant Taxonomy. Based on the results of this study, describe how would you organize information about insectivorous plants? Would this information be presented in a single lecture or at different times through the semester? Why?

ESSAY QUESTIONS: BIOINFORMATICS (choose one of two, 100 pts)

1. For the paper by Manoharan et al. (2008), answer the following questions. Your answers should be written as complete sentences in your own words, and not as lists or fragments.

A. What is the primary question that the authors are attempting to address?
B. In the simulation flow chart (Fig. 3), the 'oracle' plays a vital role. Explain the function of the 'oracle' and contrast that role with a human electronic key user.
C. What is the purpose of 'smoothing' the probability of unseen species?
D. Compare and contrast Laplace and Good–Turing smoothing.
E. Which smoothing algorithm works better on the data presented by Manoharan et al. (2008)? If you were to write your own electronic keying software, which algorithm would you use? Why? Please cite specific tables/figures in your answer.
F. Does the addition of abundance data improve the keying experience? Is a precise estimate of species abundance needed? Please cite specific tables/figures in your answer.
G. Disregarding abundance data, are some species intrinsically easier to identify than others? Provide a biological explanation for this phenomenon.

2. For the paper by Pertsemlidis and Fondon (2001), answer the following questions. Your answers should be written as complete sentences in your own words, and not as lists or fragments.

A. What is the difference between similarity and homology? Are similar sequences homologous? Are homologous sequences similar?
B. Compare and contrast PAM and BLOSUM scoring metrics. Could you use these metrics for nucleotide sequences? How?
C. In the first step of the BLAST algorithm, the query is broken up into small 'words' which are used to generate possible close–matching words using the scoring matrix. Why is the scoring matrix used? Would different scoring matrices give different results?
D. BLAST searches output an expectation (E) value. What is the meaning of this statistic?

SESSION III. AFTERNOON (TOTAL 300 pts)

Instructions: Answer one essay in each of the three subject areas (Phytochemistry, Plant Physiology, Plant Development) (100 pts each essay, for a total of 300 pts). For each topic area, students should choose one of the two essay questions.

ESSAY QUESTIONS: PHYTOCHEMISTRY (choose one of two)

1. For the paper by Wang *et al*., 1999, answer the following questions. Your answers should be written as complete sentences in your own words, and not as lists or fragments.

A. What is the principle hypothesis or the research question addressed in this paper?
B. Define what are reactive oxygen species, and why they may be harmful to humans.
C. What are anthocyanins, and how are they made by plants?
D. In Figure 1, what trends are seen for the anthocyanin, what are the controls, and are the difference significant compared to the controls?
E. Discuss the conclusions of the research and give an example of how you would change the study if you were to repeat it.

2. For the paper by Pauli *et al.*, 2008, answer the following questions. Your answers should be written as complete sentences in your own words, and not as lists or fragments.

A. What is the principle hypothesis or the research question addressed in this paper?
B. What is the difference between ursolic acid and betulinic acid, and how are these compounds produced in plants?
C. What is NMR, and list two advantages it has over other techniques for determining compound purity.
D. Using the data in Table 2, explain how the purity of ursulic acid impacts its activity against TB.
E. What implications does this research have for researchers looking at biologically active constituents from plants?

ESSAY QUESTIONS: PLANT PHYSIOLOGY (choose one of two)

1. Answer the following questions about the paper by Tognetti et al. (2006). Your answers should be written in your own words.
   A. Briefly describe how the authors evaluated if the bacterial flavadoxin could exert a protective function in planta focusing on the different transgenic lines used in the study.
   B. What is SDS-PAGE? How did the authors demonstrate that flavadoxin could sustain thylakoid electron transport in vitro?
   C. Ferredoxin is an important iron sulfur protein required in photosynthesis. Explain the electron transport system and Calvin cycle and the role of ferredoxin in photosynthesis.
   D. Iron is an essential nutrient for plant growth and often limited in soils. In a more recent paper, these authors have used these transgenic tobacco lines to study the effect of iron starvation. What do you think was the main objective of this study? If you were to propose a study to investigate the effect of iron starvation using these transformants, explain the hypothesis, design and expected findings of your study.

2. Answer the following questions about the paper by Stacey et al (2008). Your answers should be written in your own words.

   A. The authors in an earlier paper (Koh et al., 2002) have identified nine OPT orthologs in Arabidopsis. How would you assess tissue specific expression pattern of each of these OPTs?
   B. In figure 3B, there was no expression of *AtIRT1* in the shoots of both Col-0 and *opt3-2*. What do you think is the function of IRT1 in Fe movement and accumulation in plants? Why did the authors determine *AtIRT1* and *AtFER1* expression in the Col-0 and *opt3-2* plants?
   C. The authors hypothesize that AtOPT3 is likely involved in mobilization of Fe to developing seeds but unlikely that it is critical for Fe mobilization through the xylem transport system. Why? So, what is the likely function of AtOPT3 in Fe metabolism? Where in the xylem/phloem transport system is the OPT3 involved?
   D. Based on the results of this study, explain in detail the mechanism of Fe transport (xylem and phloem) from the soil solution to the possible final locations in aerial tissues, discussing the various transport mechanisms that would be required to traverse this distance. In particular, highlight the difference in Fe transport and accumulation between the Col-0 and *opt3-2* plants.

ESSAY QUESTIONS: DEVELOPMENTAL BIOLOGY (choose one of two)

1. Answer the following questions about the paper from Barkoulas et al. (2008). Your answers should be written in your own words, as complete sentences, and not as lists or fragments.

A. State the hypothesis being investigated in this paper.
B. What are the major result(s) of this paper and how were these determined?
C. For each Figure (1-4), list the controls used. For each control, explain why this was a good control or not.
D. Based on the findings of this paper, propose a project to further investigate leaf development in the land plants. Briefly, state your hypothesis, the experiments you would perform and discuss your expected findings for each.

2. The paper by Kramer et al. (2007) is one of the first to test experimentally the conservation of the ABC model of floral organ identity in a species outside of the core eudicots, specifically a non-core eudicot. Provide answers for the following in your own words, written in complete sentences.

A. Briefly define the following terms:
i. paralog
ii. heterodimer
iii. homeotic transformation

B. Briefly describe the ABC model. Why do we think the molecular mechanisms that regulate flower development may be different within the core eudicots than in other angiosperm species?
C. What sort of data can be obtained through *in situ* mRNA hybridization?
Summarize the *in situ* results for the *AP3* and *PI* orthologs of *Aquilegia* in two or three sentences. Explain how they are consistent with the ABC model and how they differ.
D. B-function genes ordinarily do not play a role in sepal identity, but Kramer et al. expected that they might in *Aquilegia*. Why? Explain their *in situ* and VIGS results regarding sepal identity. What do they conclude regarding the role of *AP3* and *PI* orthologs in sepal identity and sepal morphology in *Aquilegia*?