**PH.D PROGRAM IN BIOLOGY--CITY UNIVERSITY OF NEW YORK**
**FIRST EXAMINATION**
**ECOLOGY, EVOLUTIONARY BIOLOGY AND BEHAVIOR**
**SPRING 2003**

## Section 1—Evolution

The evolution exam is divided into 2 parts, each with equal weight.

**Part 1-1**. Answer 4 of the following 6 "shorter-answer" questions. Your answers should be thorough but terse, running no more than 1-2 paragraphs and covering no more than a single exam form page. In writing your answers, be sure to define all the relevant terms in addition to comparing terms (where appropriate).

1. Compare and contrast sympatric and allopatric speciation.

2. What is the Hardy-Weinberg equilibrium and how can it be useful?

3. What is $N_e$, the effective population size? What makes it often differ from the census population size?

4. Compare and contrast punctuated equilibrium and gradualism.

5. What is epistasis? How might it be related to linkage disequilibrium?

6. What is Fisher's Fundamental Theorem? Does it lead to the conclusion that traits with high heritability are not closely related to fitness? Why/why not?

**Part 1-2**. Answer 1 of the following "longer-answer" questions. Your answers should be thorough but, again, terse, running no more than 4 exam form pages. Be sure to define important terms.

1. In his paper *Widespread loss of sexually selected traits: how the peacock lost its spots*, Weins notes that, while sexual selection theory is much about the gain of elaborate male sexual characters and female preference for them, there has been a phylogenetically wide-spread loss of these traits. First, do his data support this conclusion? Second, what mechanisms may be responsible for the losses? Finally, what sort of research is required to clarify these issues?

2. Imagine a population that has maintained a reasonably stable population size for a long time period. Imagine further that the population size is dramatically reduced to less than 10% of its long-term stable size and assume that this reflects some random process so that the ratio of effective to census population size is unchanged. How would you measure the genetic effects? What are the immediate consequences for the population and its members? What are the longer-term effects?

3. In *Kin selection: fact and fiction*, Griffin and West note that while Hamilton's notion of inclusive fitness is useful in explaining a variety of phenomena (including especially the evolution and maintenance of altruism), the importance of inclusive fitness and kin selection may be overestimated. They explain that even though relatedness of interacting individuals is often taken as evidence for the importance inclusive fitness, relatedness *per se* is not sufficient proof. Their arguments are related to both competition and direct fitness (as opposed to indirect fitness that accrues through inclusive fitness theory). What are their arguments and some of their examples? What sort of research is needed to clarify these issues?

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## Section 2—Ecology

The ecology exam is divided into 2 parts, each with equal weight.

**Part 2-1**. Answer 4 of the following 7 "shorter-answer" questions. Your answers should be thorough but terse, running no more than 1-2 paragraphs and covering no more than a single exam form page. In writing your answers, be sure to define all the relevant terms in addition to comparing terms (where appropriate).

1. What is ecological succession?

2. Compare and contrast exponential and logistic population growth.

3. What is a trophic cascade?

4. Compare and contrast top-down versus bottom-up regulation.

5. What is a keystone species?

6. What is the competitive exclusion principle and how realistic is it?

7. Compare and contrast Food Chains and Food Webs and discuss what limits the extent (or length) of these systems of energy transfer.

**Part 2-2**. Answer 1 of the following "longer-answer" questions. Your answer should be thorough but, again, terse, running no more than 4 exam form pages. Be sure to define important terms.

1. As explained in Caswell's paper *Prospective and retrospective perturbation analyses: their roles in conservation biology*, the two types of perturbation analyses provide insightful answers to very different questions. Problems arise, however, when a good analysis is used to provide answers to the wrong question, especially when the answers are used to form management policy. Discuss the two types of analyses and their relation to the questions they were designed to address. Explain the problems associated with using retrospective analyses to formulate management policies aimed at solving current and future problems.

2. In the Posey et al.'s paper *Top-down versus bottom-up limitation in benthic infaunal communities: direct and in-direct effects* the researchers perform a number of experiments designed to determine the importance of top-down versus bottom-up controls on aquatic, benthic communities. Please compare and contrast these "opposing" controls on communities and explain what types of factors can "mask" changes in communities driven by these types of controls. It may be useful to draw on "lakes versus open oceans' when answering this portion of the question. Additionally, provide a brief summary of the results obtained from the paper and describe additional studies that could be performed to further understand top-down versus bottom-up controls on communities.

**3.** Animals that have evolved to occupy an underground ecological niche encounter different ecological and physiological constraints. In turn, subterranean inhabitants may have a dramatic impact upon their environment. For example, the maze-like burrows of mole-rats are constantly in a state of flux such that the soil substrate is constantly being modified and this can impact upon both microfauna and flora as well as on the plant community below and above ground. Food location underground is thought to be a random blind process that in arid habitats (where food is sparsely distributed) may be

energetically expensive. This phenomenon may in turn have lead to the evolution of complex social behaviors of certain arid underground inhabitants. a) Discuss the potential ecological impact of underground mammals (such as mole-rats) on their environment. b) Give two ecological and physiological advantages and two disadvantages associated with a strictly subterranean existence; explain your answers. c) Explain how living socially may alter the ecological constraints facing underground mammals.

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## Section 3—Systematics

The systematics exam is divided into 2 parts, each with equal weight.

**Part 3-1.** Answer 4 of the following 7 “shorter-answer” questions. Your answers should be thorough but terse, running no more than 1-2 paragraphs and covering no more than a single exam form page. In writing your answers, be sure to define all the relevant terms in addition to comparing terms (where appropriate).

1. Compare and contrast synapomorphy, convergence, parallelism, reversal, and symplesiomorphy.

2. Distinguish cladogenesis and anagenesis.

3. What is an outgroup and what is its function?

4. Compare and contrast monophyly, paraphyly, and polyphyly; give an example of each.

5. Identify and distinguish 3 forms of weighting.

6. What is Hennig's auxilliary principal and why is it important?

7. What is the difference between Jukes-Cantor (JC), Felsenstein 81 (F81), Kimura Two Parameter (K2P) and Hasegawa-Kishino-Yano (HKY85) models of DNA substitution?

**Part 3-2**. Answer 1 of the following “longer-answer” questions. Your answer should be thorough but, again, terse, running no more than 4 exam form pages. Be sure to define important terms.

1. Several "schools of thought" have jockeyed for the attention of systematists over the last 50 years, specifically Evolutionary Taxonomy, Numerical Taxonomy (Phenetics), Phylogenetic Systematics (Cladistics) and Statistical Systematics (Likelihood, Bayesianism). Discuss the similarities and differences between at least 3 of these "schools" in terms of how they view evidence and how they group taxa.

2. The concept of "support" and methods to measure it are common features of modern phylogenetic tree construction and presentation. Discuss three of these approaches.

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## Section 4—Behavior

The behavior section is divided into 2 parts, each with equal weight.

**Part 4-1** – Answer 4 of the following 6 "shorter-answer" questions. Your answers should be thorough but terse, running no more than 1-2 paragraphs and covering no more than a single exam form page. In writing your answers, be sure to define all the relevant terms in addition to comparing terms (where appropriate).

1.
   a. What is the definition of "helping behavior"?
   b. Give 1 example of helping behavior in nature.
   c. Describe what data one would need to obtain in the field to demonstrate that "helping" was in fact occurring.

2.
   a. What do behavioral biologists mean by the term "sociality"?
   b. How would you distinguish between "sociality" and a group of animals that just happened to aggregate in the same place at the same time?

3.
   a. Discuss the concept of deception in animal communication.
   b. How can a biologist determine whether an animal is being deceptive (that is, what criteria would be needed to "prove" that deceptive behavior had transpired)?
   c. Provide at least one inter- and one intra-specific example.

4. Compare and contrast parental manipulation and kin selection as explanations for the presence of sterile worker castes in insects.

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   a. What is a Fixed Action Pattern? Give an example.
   b. What is a Super releaser? Give an example.

1. Discuss the physiological basis of one of the following
   a. vocal production in birds,
   b parental behavior in rodents, and
   c predator/prey detection in moths and bats.

**Part 4-2** – Answer 1 of the following "longer-answer" questions. Your answer should be thorough but, again, terse, running no more than 4 exam form pages. Be sure to define important terms.

1. The paper "Behavioral flexibility and invasion success in birds" by Sol, Timmerman and Lefebvre addresses why some introduced (alien) species are successful invaders but most are not. Their thesis is that the decisive differences between theses groups of species are 1) (relative) Brain size and 2) Behavioral flexibility.

   For the first part of this question, critique the authors' argument. Does their analysis successfully support their argument? Be specific about their use of statistical analysis and the quality of the original data (e.g. might there be biases inherent to the data or way they were collected).

Second, assuming for the moment that the authors are correct in their main assertions, how might these conclusions about behavioral flexibility impact current ideas of Optimality? Put another way, would proponents of Optimal Foraging Theory accept these conclusions about behavioral flexibility? Can the overall conclusion about what makes a successful invader be embraced within the context of Optimality reasoning?

2. No longer do researchers search for THE cue that is used in navigation and orientation. Now researchers search for the hierarchy of cues asking for example, how can it be demonstrated that a pigeon uses cue A in preference to cue B in certain situations. Pigeons use the sun and the earth's magnetism as cues for example to find their way home. If home is to the south, in which direction would you expect pigeons to fly under the following conditions?

    a. sunny skies, no magnets on bird
    b. sunny skies, magnets on bird
    c. overcast skies, nonmagnetic magnet-sized pieces of brass ("brassies") on bird
    d. overcast skies, magnets on bird
    e. at midnight, with both magnets and brassies but the pigeon has been transported to the release site in total darkness, anesthetized, rotated in a dark box and with the magnetic field reversed at the same time.

3. A field observer finds that in the species she is studying groups with helpers have more mature offspring than groups without helpers. Discuss several possible causes of this correlation. Describe an experiment that would allow you to determine which hypotheses could be rejected.

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# Required Reading List

## Some questions are based on the following Journal Articles and web resources:

**Behavior**:

Sol, D., S. Timmermans, and L. Lefebvre. 2002. Behavioral flexibility and invasion success in birds. *Animal Behavior* 63: 495-502

**Evolution**:

Griffin, A. S., and S. A. West. 2002. Kin selection: fact and fiction. *TRENDS in Ecology & Evolution*, 17: 15-21.

Wiens, J. J. 2001. Widespread loss of sexually selected traits: how the peacock lost its spots. *TRENDS in Ecology & Evolution*, 16: 517-523.

A journal we encourage students to read is *TRENDS in Ecology and Evolution*: *TREE*

**Ecology**:

Caswell, H. 2000. Prospective and retrospective perturbation analyses: their roles in conservation biology. *Ecology*, 81: 619-627.

Posey, M. H., T. D. Alphin, L. B. Cahoon, D. G. Lindquist, M. A. Mallin, and M. B. Nevers. 2002. Top-down versus bottom-up limitation in benthic infaunal communities: direct and indirect effects. *Estuaries*, 25: 999-1014.

**Systematics**:

On the internet, consult links at the bottom at www.cladistics.org/education.html

## Books

**Behavior**:

Krebs, J. R. and N. B. Davies, editors. 1997. *Behavioural Ecology: An Evolutionary Approach*, 4th Ed. Blackwell Science Inc., Boston.

Goodenough, J., B. McGuire and R.A. Wallace. 2001. *Perspectives on Animal Behavior*. Second Edition. John Wiley & Sons, New York.

**Evolution**:

Freeman, S., and J. C. Herron. 2001. *Evolutionary Analysis*. Prentice Hall, Upper Saddle River. 704 pp.

**Ecology**:

Riklefs, R., and G. L. Miller. 1999. *Ecology*, 4th ed. W. H. Freeman & Co. (or equivalent comprehensive ecology text)

Recommended: Gotelli, N. J. *A primer of ecology*. Sinauer. This is a good book on mathematical ecology.

**Systematics**:

Schuh, R. T. 2000. *Biological systematics: principles and applications*. Cornell Univ. Pr. [ read especially Chapters 1, 2, and 3]

DeSalle, R., R. Giribet, and W. Wheeler. 2002. *Techniques in molecular systematics and evolution* Basel, Birkhäuser. 420 pp. [read especially chapters 1, 2, and 5]

Also recommended: Hillis, D. M., C. Moritz, and B. K. Mable. 1996. *Molecular systematics*, 2nd ed. Sinauer.