Biology 211 | **College of Charleston**
Biodiversity, Ecology, and Conservation Biology | **Dr. Bob Podolsky**

EXAM 1 Study Guide

Exam 1 will include a mix of question types: identifications, multiple choice, single choice, short answer, fill-in-the-blank, true-false, problem solving, and short answers. This study guide will help to review the concepts and skills covered in lecture and readings, but is not an exhaustive list of actual questions that could be on the exam. Because some questions will ask you to apply what you've learned to a new problem, you will not be well served by only reading the questions below and thinking you know the answer because you remember hearing about it. You should write down answers and work through the problems in detail. **The best way to check your understanding of the concepts is to have someone else ask you the questions and force yourself to explain answers out loud**. For this reason I recommend studying in groups and asking each other questions only after you have studied by yourself to learn the material.

Be able to use the following formulas and to be able to explain what their components mean:

$\chi^2 = \sum (O-E)^2/E$, threshold value 3.84

$N_{t+1} = N_t + B - D = N_t + br - dr$

$\Delta N/\Delta t = rN$

$\Delta N/\Delta t = r_{max} N (1-(N/K))$

$R = S \times h^2$

$R_o = \sum l_x \bullet m_x$

Unit 1. Biodiversity and conservation biology

1) Be able to define the following words and phrases: biodiversity, genetic diversity, species diversity, endemic, conservation biology, fragmentation, core habitat, edge effects, invasive species, keystone species, biodiversity hotspot, conservation hotspot.

2) Explain why biology can be thought of as an "inherently hierarchical" science.

3) Discuss two distinct ways that biodiversity is organized hierarchically at levels higher than the organism.

4) Explain four general reasons why biodiversity is considered to be worth maintaining.

5) Describe how the current extinction rate compares to historical rates of extinction

6) In what specific ways does habitat fragmentation pose a threat to biodiversity?

7) Explain the conservation issue and biological question addressed in the paper by Reid et al. (2013), their experimental approach, and the major conclusions they drew.

Unit 2. Population and conservation genetics

1) Be able to use and distinguish the following words and phrases: population, evolution, quantitative trait, polygenic, phenotypic variation, genetic variation, phenotypic plasticity, heritability, natural selection, strength of selection, response to selection, fitness, allele frequencies, genotype frequencies, gene pool, Hardy-Weinberg equilibrium, mutation, migration, gene flow, genetic drift, sampling error, fixation, founder effect, bottleneck, random mating, assortative mating, inbreeding, inbreeding depression, heterozygosity.

2) Explain how continuous, quantitative variation at the phenotypic level can arise from discrete alleles at the genetic level. Be able to walk through an example.

3) Consider head circumference in humans. Is this trait likely to show genetic variation? Is it likely to show phenotypic plasticity?

4) Explain why traits must have a genetic basis to evolve in response to natural selection.

5) Is natural selection possible without evolution? Is evolution possible without natural selection? In each case explain why.

6) Evaluate the following statement: the evolutionary response to natural selection is always smaller than the strength of selection. Give a numerical example to support your answer.

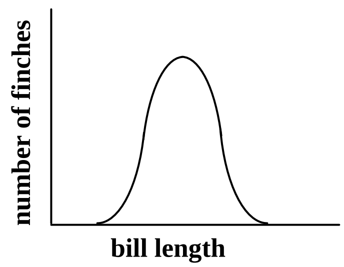
7) Recall graphs that show the effect of genetic drift on allele frequencies. For two populations, what two features of their changes over time can be used to tell their relative sizes?

8) What two features of allele and genotype frequencies are needed to show that a population is staying in Hardy-Weinberg equilibrium? What five processes are assumed not to be changing those frequencies?

9) Be able to (1) calculate allele frequencies from genotype frequencies, (2) calculate predicted genotype frequencies if a population is in Hardy-Weinberg equilibrium based on allele frequencies, (3) determine whether observed frequencies are in Hardy-Weinberg equilibrium.

10) For two alleles, be able to determine whether a given set of genotype frequencies is possible for a given set of allele frequencies.

11) The figure to the right shows the distribution of bill length in a population of finches. Graph the expected distribution of bill length in this population after several generations of selection for larger bill size. In one case, assume that bill length shows heritability. In another case, assume that bill length has zero heritability.



12) Be able to explain how, why and in which direction *genetic drift* and *gene flow* are expected to influence genetic diversity <u>within</u> populations.

13) Be able to explain how, why and in which direction *genetic drift* and *gene flow* are expected to influence genetic diversification <u>between</u> populations.

14) How do *gene flow* and *genetic drift* combine to threaten populations in fragmented landscapes?

15) Construct an everyday example of sampling error different from those described in class.

16) What does it mean for an allele to reach "fixation"? How is it possible for allele frequencies to change once fixation has occurred?

17) Which of the five population genetic processes can lead to a population being better adapted to its environmental conditions?

18) On its own, how is inbreeding expected to affect allelic diversity in a population? How is it expected to affect genotype diversity?

19) Explain why mutts (mixed breeds) tend to live longer than purebred dogs.

20) Conservation managers often try to purchase corridors of undeveloped habitat so that larger preserves are linked into networks. Why? As specifically as possible, what genetic goals are they aiming for? Describe two effects of corridors on population genetic structure. Use the populations of prairie chickens described in the article by Westemeier et al. as an example.

21) In the mid-1980's, conservation biologists made a difficult recommendation: give up trying to preserve captive populations of <u>all</u> endangered cat species in favor of maintaining larger numbers of just <u>a few</u> endangered cat species. For example, some biologists recommended stopping efforts to breed the extremely rare Asian lion, the beautiful species seen in Chinese artwork. By reducing the number of species kept in captivity, the biologists hoped to increase the captive population size of each of the remaining species. Why did they argue that this strategy was worth the risk of losing the rare Asian lion forever?

Unit 3. Population dynamics

1) Be able to distinguish and use the following words and phrases: Allee effect, demographic stochasticity, environmental stochasticity, population dynamics, birth, death, immigration, emigration, intrinsic effects, exponential growth, carrying capacity, density independent, density dependent, logistic growth, intrinsic rate of increase, age structure, age class, survivorship, survivorship curve, fecundity, life table, life history, allocation, trade-off, dispersal, metapopulation, rescue effect, population viability analysis.

2) Describe two distinct risks of small population size and why these risks are less likely to threaten large populations.

3) Describe an example of how year to year environmental variation can threaten a population with a limited range.

4) What are the four basic processes that contribute to changes in population size?

5) What are the biological conditions under which populations can show exponential growth? Give an example.

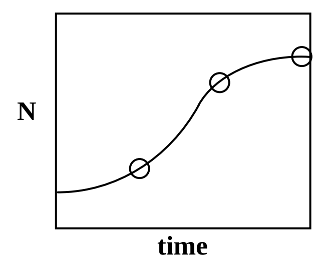
6) What are some specific biological constraints that put a limit on exponential growth? Give an example.

7) Explain how incorporating the parameter **K** changes the exponential growth equation to the logistic growth equation.

8) List at least three density-dependent processes that can limit population size.

9) Which population model is currently more appropriate for: 1) a population of bacteria that have just colonized your nasal passages? 2) A population of elephants? 3) The human population? 4) A newly invasive plant species? 5) An established population of fruit flies in a jar in the lab?

10) For each of the three areas circled on the figure to the right, describe if and how the quantity $\Delta N/\Delta t$ is changing from one time to the next. For each point, explain why $\Delta N/\Delta t$ changes in the way it does relative to the other time points, or why $\Delta N/\Delta t$ does not change.



11) Be able to use the exponential growth equation to find population size after five time steps.

12) Be able to use the logistic growth equation to find population size after five time steps.

13) Can populations ever exceed their carrying capacity? Why or why not?

14) How can the metapopulation concept help to design better ecological reserves? What is the risk of ignoring the fact that some species are structured as metapopulations?

15) How is an increase in habitat fragmentation likely to affect the dynamics of a metapopulation?

16) Are all individuals in a population likely to contribute equally to changes in population size? Support your answer with an example.

17) In particular, what can a life table for an endangered species tell a conservation biologist?

18) Discuss how maturation rate (age of first reproduction) can affect population dynamics. Why are certain slow-growing, large-bodied, late-maturing organisms, like sea turtles, particularly vulnerable to over-exploitation?

19) Why are trade-offs thought to be so common among life history traits?

20) Describe changes in three factors that could lead to an increase in population growth rate for an endangered species.

21) Explain why a genotype that has the highest fecundity may not have the highest fitness. Explain why a genotype with the highest survival may not have the highest fitness. Relate this issue to theories about why organisms senesce.

Sample problems

1) Suppose you found a great deal of variation in swimming speed within a population of Atlantic salmon. Describe an experiment that you could use to test the degree to which variation in swimming speed in this population of fish is heritable. Draw a graph representing the results you would expect if heritability of swimming speed is high, and a second graph representing the results you would expect if this trait is not heritable.

2) Imagine that you're interested in the evolution of distastefulness in ladybugs. Imagine that you measure distastefulness in a population of ladybugs before and after exposing them to predation by birds. You find that the mean distastefulness in adults before natural selection is 5.0 BTU (bad-taste units), while the mean distastefulness in the same generation of adults after predation is 6.0 BTU. You continue to follow this population and find that the mean distastefulness in the next (offspring) generation is 5.6 BTU. Calculate (a) the strength of selection on ladybug distastefulness and (b) the heritability, h^2, of distastefulness.

3) A single gene is thought to determine whether your earlobes are attached or free-hanging, with the recessive allele coding for attached earlobes. In a population of 485 people, 100 are homozygous dominant, 240 are heterozygous, and 145 are homozygous recessive (and therefore have attached earlobes). (a) What is the frequency of the dominant allele in this population? (b) Is the population in Hardy-Weinberg equilibrium? Show all of your work.

4) The frequency of the sickle-cell allele, HbS, in the African-American population is 0.04. What is the frequency of the normal allele, HbA (assume these are the only two alleles)? If the population is in Hardy-Weinberg equilibrium, what percentage of the population is predicted to be carriers (heterozygotes) of sickle-cell disease?

5) Cystic fibrosis, a disease common in populations of European descent, is caused by a <u>recessive</u> allele. The frequency of the cystic fibrosis (CF) allele in these populations is stable at 0.02. If the population were in Hardy-Weinberg equilibrium, how frequently would the disease be expressed among newborns?

6) Using information from question 5, if the fitness of both homozygous normal individuals and heterozygous individuals is 1, the fitness of individuals with cystic fibrosis is 0, and there is no mutation, how is the frequency of the CF allele expected to change over one generation?

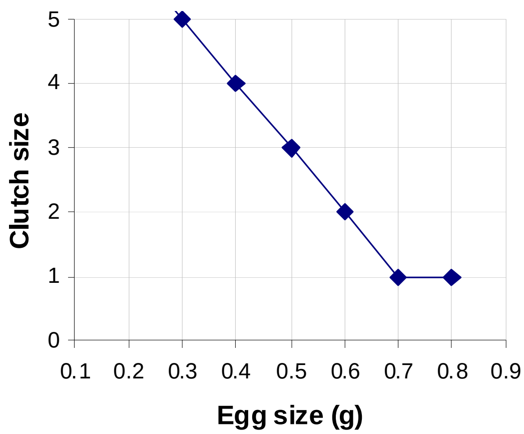
> (An aside: As medical treatments have improved, the expected lifespan of CF patients has increased to nearly 40 years of age; however, CF often leads to male infertility and can also reduce female fertility. Consequently, while the average biological fitness of CF patients is no longer zero, it is reduced relative to the non-CF population.)

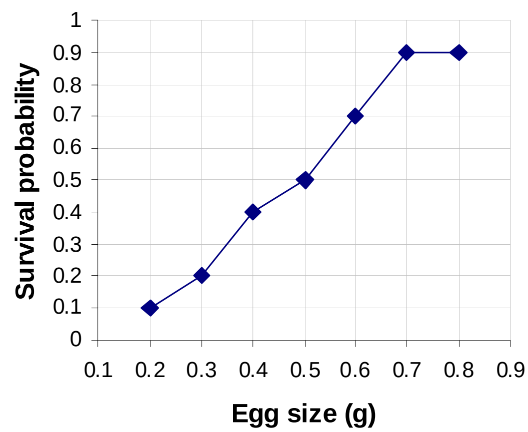
7) A population of *Streptococcus* bacteria has an intrinsic rate of increase of 0.6. What can you deduce about birth vs. death rates for this population? How many generations of exponential growth would be required for this population to at least triple in size?

8) Rabbits were introduced to Australia by Thomas Austin, who brought 24 wild rabbits from England in 1859 and released them on his property in Australia. Without their natural predators, competitors, and diseases, the rabbit population grew exponentially. If the <u>annual</u> per capita rate of population growth was 1.2, how many rabbits would there have been 5 years later? (Fractions of rabbits are not allowed—they should be rounded down each time step, in this case, each year.)

9) Consider the population of stray cats on the C of C campus. The campus has a carrying capacity of 100 stray cats and the maximum intrinsic rate of increase per generation for this cat population is 1.8. The generation time is 5 years. Starting with 5 cats in 2010, calculate and plot the number of cats in this population censused every five years for the next 20 years (until 2030). (Fractions of cats are not allowed—they should be rounded down each time step, in this case, each generation).

10) Examine the graphs below, which show how clutch size and offspring survival depend on egg mass in a species of bird. Which graph shows a tradeoff? After appropriate calcualtions, determine the optimal clutch size in this species. Show your work.





11) You are tracking a cohort of **10000** cricket frog eggs in a population Based on the information in the life table to the right, predict how many frogs from the original cohort will be alive when they reach reproductive maturity (adulthood). On average, how many *total* offspring are produced by a female cricket frog during her second reproductive year? What type of survivorship curve does this population display?

stage	survivorship	fecundity (per female)
Eggs	1.000	0
Embryos	0.850	0
Tadpoles	0.050	0
Juveniles	0.010	0
First-year adults	0.002	120
Second-year adults	0.001	150

12) You are tracking a cohort of 1000 lizards that hatched from eggs in January 2008. Imagine that 80% of the hatchlings survive to 2009. Of those that survived to 2009, 25% survive to 2010. Of those that survived to 2010, 20% survive to 2011. And of those that survived to 2011, 50% survive to 2012. By 2013 none of the original cohort are alive. You also find reproduction rates in this cohort to be 6 offspring/female in 2010 and 10 offspring/female in 2011, with zero in other years. Construct a life table for this population that includes *x*, l_x and m_x. Based on numbers that can be calculated from the life table, will the population grow, shrink or remain stable? Justify your answer.