Before you start please write your name on the top each page!

Read each question carefully before answering to ensure that you fully understand what the question is looking for. Answer the questions in sufficient detail to let us know that you fully understand the critical issues. Do not use the shotgun approach of throwing everything under the sun into your answer in the hope that something will hit the target because we may deduct points for statements that are counter to the correct answer.
The last page is scratch paper for organizing your thoughts.
70 Points total. Good luck.

1. You observe three different species of an organism that **look similar** in morphology (maybe they are closely related, and maybe they are not), but each species is restricted to a different southern continent (a different species in Australia, South Africa, and South America, respectively). Describe three mechanisms (hypotheses) that could account for this observed distribution. (Describe the process, don't just provide a name for each hypothesis). What information would be needed for you to distinguish between the three hypotheses? (6 points)

1) convergent evolution: the species are not closely related by look similar because they have ecologically similar lifestyles and natural selection has caused them to converge evolutionarily.
2) dispersal: these are the same taxa, or very closely related, and they have dispersed from one continent to the other continents
3) continental drift: the species are related and stem from an ancestral species that was found on the southern continent (Gondwanaland), and the species moved and diverged with the southern continents as they split up and moved apart.

Information needed: Are the species closely related and are they good dispersers that can cross oceans? If the species are not related, then convergent evolution is supported. If the taxa are related, and are also excellent dispersers, dispersal is supported. If the taxa are related, but are poor dispersers, continental drift is supported (time to look for fossils). dispersers.

***Many people did not say what results support which hypothesis!!*

2. Patterns of sexual size dimorphism are interesting because they not only illustrate that body size is an adaptation, but that the sexes differ in the selection pressures that select for body size. Provide (i) one example of dimorphism where males are bigger than females and (ii) one example where females are bigger than males. In each case, name a type of selection pressure that typically differs between sexes and could account for the increased size of the bigger sex (4 points).

- males larger than females: elephant seals, humans, etc…; selection for large males due to sexual selection
- females large than males: spiders, angler fish, raptors; fecundity selection in females
- sexual selection for females is a correct answer only for a few taxa like sandpipers, jacanas

3. Physiological processes scale in interesting ways with body size, and these patterns of scaling have huge implications for many ecological aspects.

i) What is the difference between whole organism metabolic rate and mass specific metabolic rate? How do each of these two measures scale with body mass (i.e. what are the values of the allometric slope 'b', for each)? (4 points).

- *whole organism metabolic rate is the metabolism (energy burned) of the entire organism*
- *mass specific metabolic rate is the fuel burned per gram of tissue; it is calculated as the whole organism metabolic rate divided by body mass*

- *whole organism metabolic rate scales **.75** to mass (stating these specific values was essential)*
- *mass specific metabolic rate scales **-.25** to mass*

ii) Two new mammals have just been discovered, a new elephant-sized beast, and a tiny shrew-sized creature. Based on what you know about the physiological consequences of body size, speculate about (i) the expected diet differences between these two species (what they eat) and (ii) the risk that a three day cold period without food poses to each. Justify your speculation (4 points)

- *mass specific metabolic rate will be huge for the tiny mammal, small for the huge animal*
- *thus, small animal eats energy rich food (nectar, insects); large eats low quality food (herbivore)*
- *endurance (time lasting on stored fat) scales .25 with body fat, tiny animal cannot last cold period without dropping metabolic rate (torpor), cold period is a piece of cake for the big animal*

(stating that big animals store more fat is not correct: you needed to mention efficiency or endurance)

4. You believe that a nasty non-native snake that was introduced into the arboretum is causing natural selection for increased body size in Arboretum Mouse. Outline a field study you could do to document such natural selection, being careful to identify all components of natural selection and to state how you would measure/show them with your field study (8 points).

*First, we need to establish a marked population of mice, where each **individual** is given a unique tag. We also measure these animals to determine whether individuals vary in body size. This is the <u>phenotypic variation</u> part of selection. Then, we need to be sure that some of this variation has a <u>genetic basis</u>. To do this, it is critically important that we can match offspring to their parents; i.e. compare the body size of adults to the body size of their mature offspring. This requires that we tag baby mice in their nests with their moms and that the baby mice do not disperse very far. Finding a positive relation between the body size of the parent mouse and the mature offspring mice would show that some of variation in body size has a genetic basis. Finally, we must show a fitness benefit to larger body size, either showing that bigger individuals survive better or have more offspring than small individuals. This is <u>the selection part of natural selection</u>. If the snake is the agent of selection, then we might suspect that bigger animals are better able to escape snake predation and likely have better survival. If the above three* *conditions are all met, natural selection will occur and there will be a change in genotypes and phenotypes across generations.*

(The critical thing was to mark individuals and document all aspects of natural selection by focusing on ***individuals****! Incomplete answers did not focus on following the fates of individuals to document the three aspects of natural selection. Many people came up with experiments to show natural selection but such experiments can be misleading: experiments can only show the third part (the selection part). Just showing a change in body size with experimental addition/removal of snakes is very weak because an alternative explanation is that snakes reduce mouse density, more food for mice, mice grow to be bigger (due to growth and nutrition, not selection for large phenotype/genotypes)*
(Simply listing the three components of natural selection did not yield many points; the question was designed to see if you could do more that just list these components from memory)

5. Experiments with 'risk-sensitive' foraging show that animals sometimes gamble.

(i) Show that you understand what 'risk-sensitive' means by describing an experiment you could perform to demonstrate whether or not the Lesser Squinting Squeaker is a 'risk sensitive' forager. (6 points)

Risk-sensitive foragers pay attention not only to the average reward from a foraging choice, but also the variation or risk of getting nothing. Train the animals on two different trays, a Constant tray that always has a reward, and a Risky tray that either offers nothing or a big payoff. Keep the average reward the same to make sure that average reward does not affect things. Then, run a series of trials and see if the Squeaker shows a clear preference for the constant reward (i.e. risk averse) or the risky reward (i.e. risk prone), either of which shows risk-sensitive foraging (i.e. the animal is sensitive to the variation, or degree of risk). If the animal shows no preference (i.e. 50% time at each tray) it is not showing risk-sensitive foraging. ***NOTE:*** *Risk Sensitive Foraging means that the individual has a preference for <u>either</u> the risky or conservative options.*

(ii) In several real studies of shrews, bees and small birds, whether or not the animals showed risk-sensitivity depended on their physiological state. Discuss this pattern and state why it makes sense (2 points).

Animals took chances (risk prone) when in energy deficit; avoided chances (risk averse) when in energy surplus. These are all tiny animals with high mass specific metabolic rates; they starve easily; thus when are in energy deficit and they have an increased risk of starvation, they need to gamble for the risky, but potentially big payoff to survive.

6. As a conservation biologist, you study an endangered annual plant, the Santa Cruz Sparkle. The plant occurs in two habitats and you seek to preserve the habitat with the <u>highest long-term population growth rate</u>. Habitat A is stable and the plant has a consistent population growth rate parameter: λ always is 1. Habitat B is unstable, and λ for that population varies – in any given year, λ has an equal probability of being 2 or 0.4. Which habitat should be preserved? Explain the full logic of your answer (4 points).

Habitat A has the higher growth rate. Growth is a multiplicative process: λ this year times λ next year, and so on. Long term growth rate is determined by multiplying the lambdas in different years. Thus, in habitat A, growth is proportional to $1 \times 1 = 1$. The growth rate in habitat B is proportional to $2 \times 0.4 = 0.8$, which is less than the growth rate in habitat A. (If students discuss geometric mean, i.e. the square root of the multiplication, even better)

7. Ecologists recognize that not all occupied habitats can produce self-sustaining populations, and distinguish between source and sink habitats (3 points).

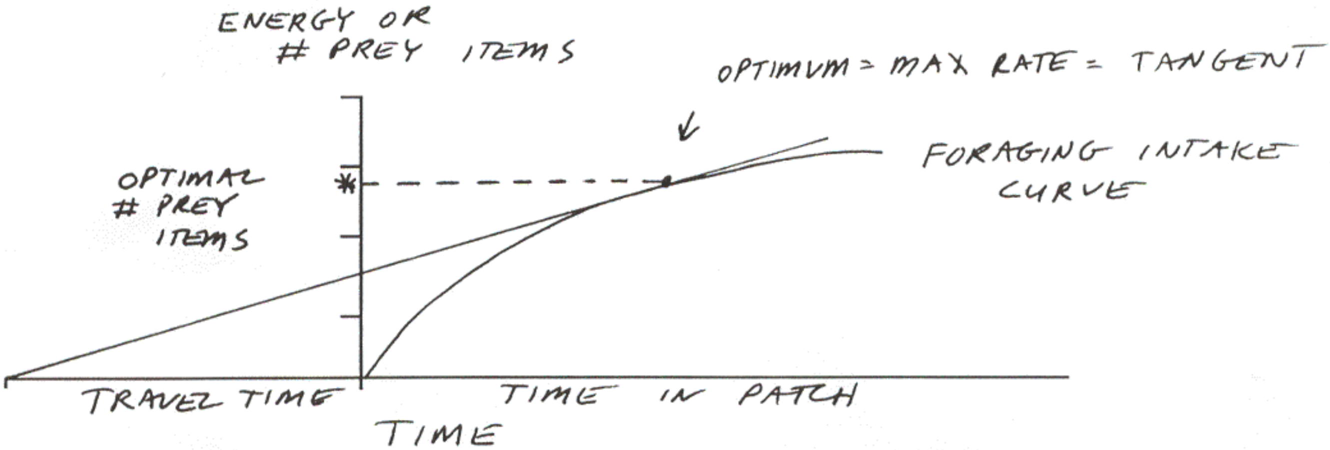
In a source habitat, λ _<u>>1</u>_________.

In a sink habitat, λ ____<u><1</u>________.

Immigration will be higher into the ____<u>SINK</u>___ habitat.

8. Graphical models of optimal foraging provide a nice way to examine the foraging decisions of an animal that is repeatedly making trips between foraging patches and a central place, as exemplified by a bird that forages for food to feed the chicks in its nest. Below is the skeleton of this graphical model which you need to complete.

- Label all axis including the two separate parts of the x axis (2 points)
- Draw the foraging intake curve for rate of prey gathered while foraging in the patch (1 point)
- Indicate how we solve for the optimal number of prey items that maximizes the **rate** of prey items returned to the nest (1 point)
- Also indicate the optimal number of prey items the forager should collect (it may not be an even number, don't worry about the tick marks) (1 point)

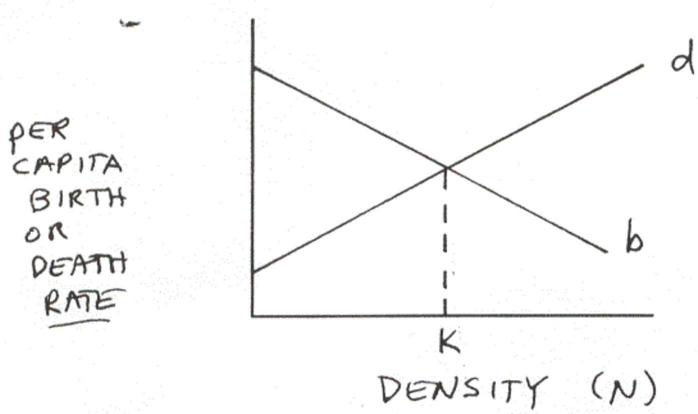


(ii) If you were to test this model in the field and found that birds do not forage as predicted, how specifically might you explain this? (1 point)

the currency is not the one the birds maximize
or the birds unable to accurately asses their intake rate

9. Density-dependence is of special interest to ecologists because it can potentially explain what limits population growth in some species.

(i) Using a graph illustrate how a density-dependent birth rate (b) and/or a density-dependent death rate (d) can "regulate" a population so that it will be stable at K, its carrying capacity. Label the axes, all lines, and explain clearly in words why the population will be stable at K (i.e. why r = 0). (5 points)

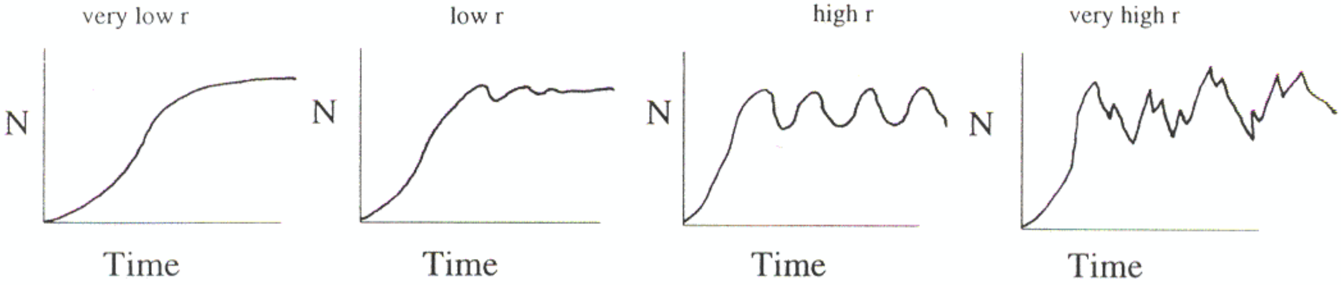


r = per capita growth rate
r = b − d
r = 0 when b = d (lines cross)
Above K b < d, r is negative, pop decline
Below K b > d, r positive, growth

(ii) Describe a mechanism that can give rise to density-dependence (1 point)

territoriality, Allee effect, resource depletion, intraspecific predation, prey switching, competition, predation, disease

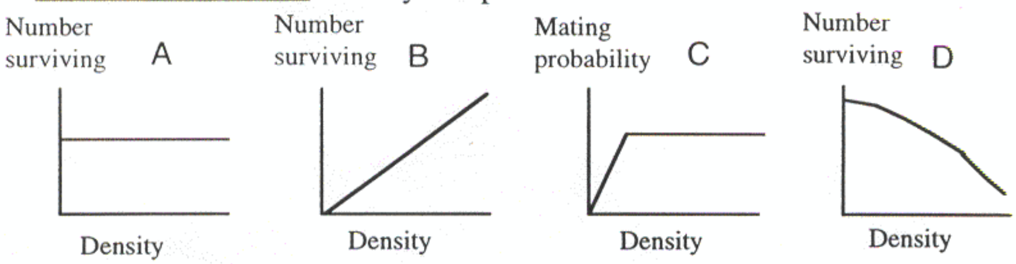
10. Two types of models can be used to model the logistic model of growth. One of these, the discrete model of logistic population growth, produces different and increasingly complex population dynamics as the value of r_D, the per individual population growth rate, increases (r_D is just another way to represent λ). Four distinct types of dynamics are produced as we increase the value of r. Draw these dynamics in the graphs below (4 points).



11. If r = 1 per day, r per week is ___7___ (2 points).

12. Ecologists recognize a variety of types of density-dependence. Four of the following five types are represented below. Match the graphs to their correct name type, and indicate which type in the list is not illustrated by a graph (write 'no graph'). (5 points).

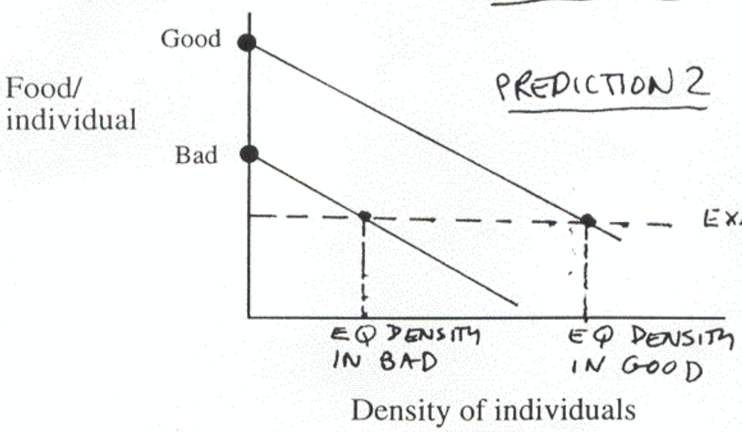
a. ___NO GRAPH___ Undercompensating density-dependence
b. ___C___ Allee effect
c. ___D___ Overcompensating density-dependence
d. ___A___ Exactly compensating density-dependence
e. ___B___ Density independence



13. The Ideal Free Distribution predicts how animals should distribute themselves among habitats to maximize their fitness, given what other individuals in the population are doing. This idea can be illustrated graphically. Complete the graph below to illustrate the Ideal Free Distribution (i.e. at equilibrium). State in words the two most important predictions of the theory, and illustrate these predictions on the graph (6 points).

PREDICTION 1 – SAME FOOD PER INDIVIDUAL IN BOTH HABITATS

PREDICTION 2 – HIGHER DENSITY IN GOOD



EXAMPLE EQUILIBRIUM – SAME FOOD/ INDIVIDUAL IN BOTH HABITATS