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. When drawing lines or curves throughout the exam, make it clear when you have drawn a straight line or a curved line!

70 Points total. Good luck.

1. The population growth rate per individual, r, is a very useful population parameter that is used in many population models.

(i) What exactly is r? Explain fully in terms of births and deaths, and be clear on whether you mean population number or individual rates. (2 points)

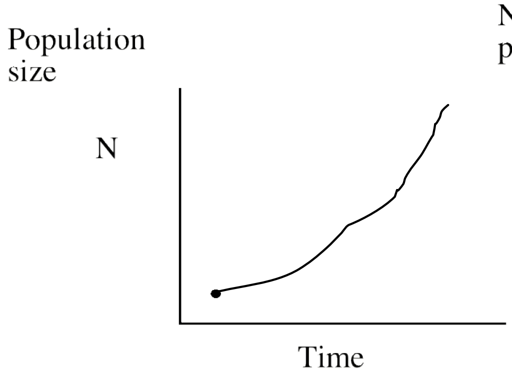
r = b - d, where b = birth rate per individual and d = death rate per individual

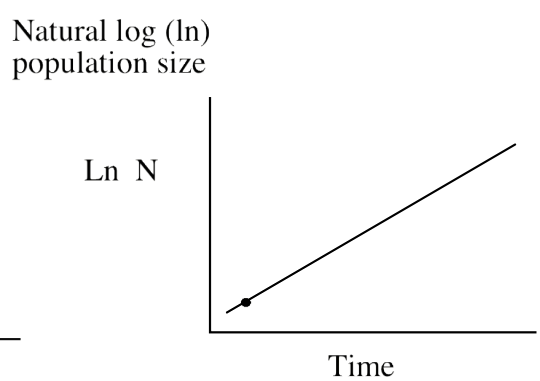
(ii) If r = 1/day, what is r per week? (1 point)

r = 7/week

(iii) If r > 0, what would the pattern of population growth look like on the two graphs below? The dot indicates the starting population size (2 points).

left panel must curve upwards, right panel must be straight line





(iv) How could you estimate 'r' from the one of the plots above? (1 points)

r is the slope of the line on the right graph

2) You suspect that ongoing natural selection is selecting for increased in body size in the Giant Mouse on Devil's Island. Your task is to design a field study to document all aspects of this natural selection in action. Start by outlining briefly the process of natural selection in general. Then describe all of the field methods needed to show each component of natural selection, as well as the outcome of natural selection, and identify what data observation is needed to confirm each of these component of selection. Your study should be an observational study, not an experimental manipulation (10 points).

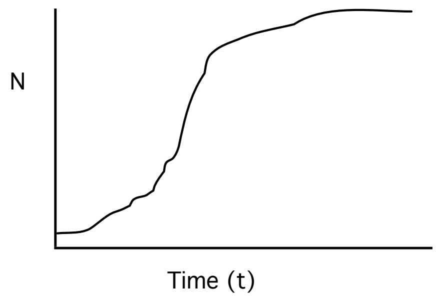
If we have following three conditions
1) phenotypic variation in a trait
2) variation (trait) is heritable
3) trait has reproductive and or survival (i.e. fitness) consequences
Then natural selection will happen, which means in the next generation after the selection, the average value of the trait will have changed (and there will have been genetic changes in the population too.

To study this in the mice, we need to capture and mark individuals (so that we can follow the fates of individuals over time). We also need to measure the body sizes of individuals to show that there is variation in body size (part 1 above). We then monitor the survival and reproduction of the mice to see who lives and dies — if natural selection favors larger mice, then we should see higher survival and/or higher reproductive output of larger individuals (part 3 above). We also must match specific parents to their offspring to see if body size is heritable. We obtain body size measurements of the kids when they grow up. Showing a positive correlation (relation) between the body size of parents and the body sizes of their adult offspring indicates that the trait is heritable (condition 2 above). If all of this is shown, then natural selection will occur. We confirm this by showing that the average body size of the next generation (i.e. the adult kids of the population we started with) has increased relative to the body size of the population of adults we started the study with.

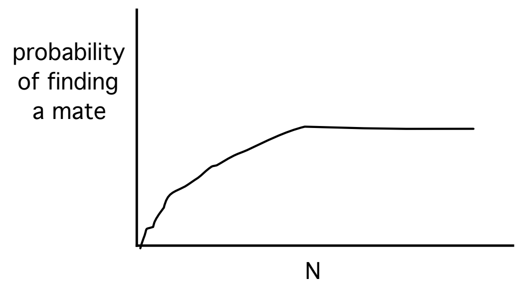
KEY

3. Fill in each graph below with the curves or lines predicted by the equation or phrase at the top of the graph beside the large letters. Take your time to draw the right shape of line and make it clear on whether you have drawn a straight line or a curved line! (6 points)

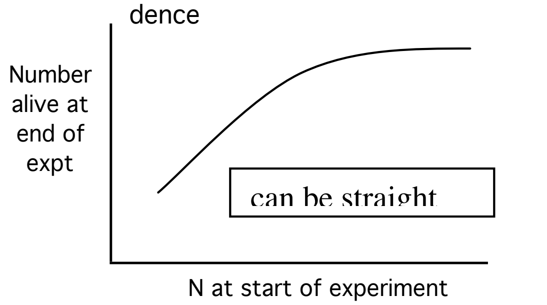
A dN/dt = rN(1-N/K) (where r > 0)



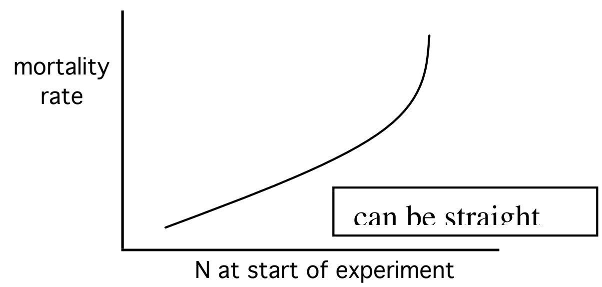
B Allee effect



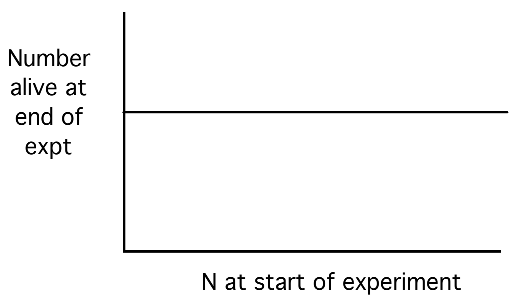
C Undercompensating density dependence



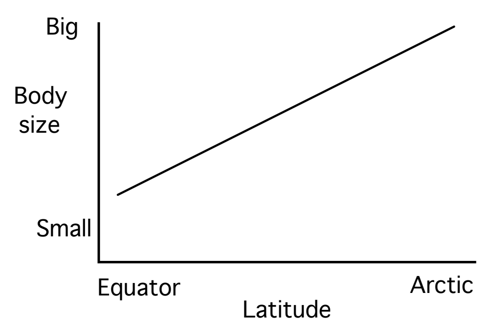
D Overcompensating den. depend.



E Exactly compensating den. dependence



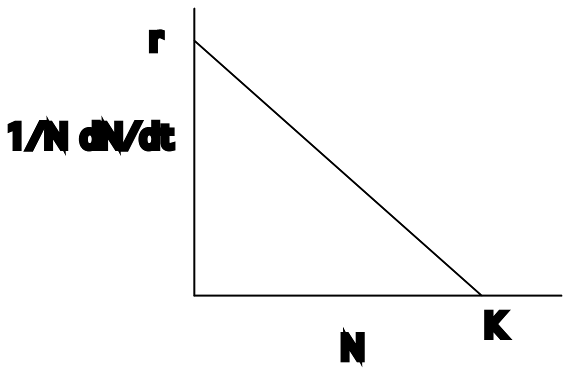
F Bergmann's Rule



4. 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 (natural/sexual) that select for body size. Provide (i) one example of dimorphism where males in a species 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 thus could account for the increased size of the bigger sex (4 points).

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

5) The logistic model of population growth is based the idea that "density-dependence" can put the brakes on population growth due to intraspecific competition for limiting resources. The logistic model is based on a very simple assumption about the relation between the per-individual contribution to population growth and population density. Complete the following graph to show the basic biological assumption behind the logistic equation. Be sure to label all axes and important points (5 points).



6. Match each biome on the left with the description on the right that best applies to it and write the letter of the description in the space provided (5 points)

1. Tropical rainforest **B**
2. Grassland **G**
3. Northern coniferous forest **A**
4. Temperate deciduous forest **D**
5. Desert **F**

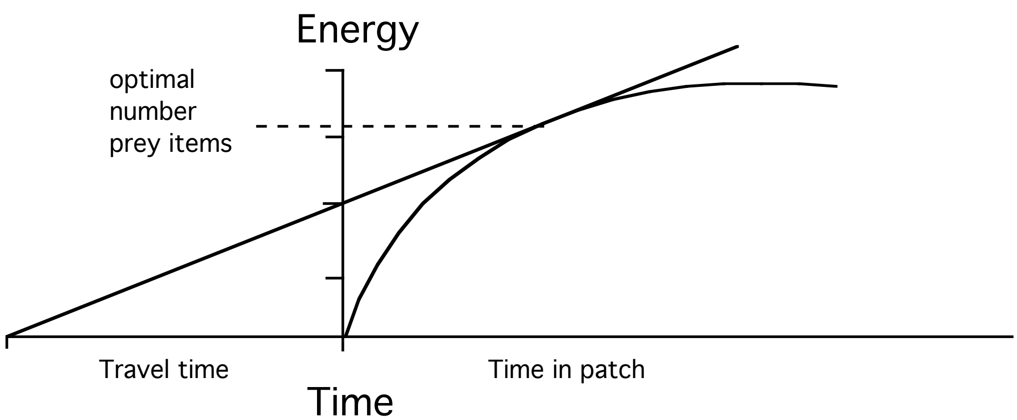
A. dramatic population cycles of mammals
B. extreme biodiversity
C. most extreme seasonality of any biome
D. spring ephemeral flowers
E. wet, warm, coniferous trees
F. concentrated at 30° N and S latitude
G. fire maintains boundary in some regions

7. You are in charge of deciding which of two populations of the rare Garcia's Deadhead to conserve and you have good annual population growth rate data for use in making this decision. Population A lives in a very unstable environment and good and bad years occur with equal frequency. In good years, population A does extremely well (annual population growth rate (λ) is 2.0), but it does poorly in bad years (λ is 0.5 in bad years). Population B lives in a very stable world and λ is always 0.95. Which population has the best chances for long-term population persistence and how do you know? (4 points)

Pop A will survive, pop B will not. Since λ for pop B is fixed at 0.95, which is always less than one, this pop will go extinct. Pop A has a variable λ but geometric mean of this λ equals 1 (hence population is stable). Geo mean is square root of 2 times 0.5 or square root of 1 = 1.

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, for example a bird that forages for food to feed the chicks in its nest. Below is the skeleton of this graphical model — complete the model as follows:

- Label all axis including the two separate parts of the x axis (2 points)
- Draw the foraging intake curve for rate of energy gathered (prey items) 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)



9. Darwin's finches on the Galapagos Island archipelago are a classic example of an adaptive radiation. However one species of Darwin's finches, the Cocos Finch, made it to Cocos Island near Costa Rica. Clearly all of these finches are close relatives phylogenetically, but the pattern of evolution in these two locations is very different. With reference to adaptive radiation, speciation and ecological specialization, compare and contrast the Darwin's finches in the Galapagos and the Coco's finch. (4 points).

Darwin's finches on Galapagos — many species; speciation possible because are many island far enough for infrequent colonization (get differentiation and speciation); ecological specialization on different food resources through species differences in morphology (beak structure)

Coco's Finch— one island, therefore no speciation and only one species; get ecological specialization through individual behavioral specialization on different food resources.

10. 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 by themselves 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.

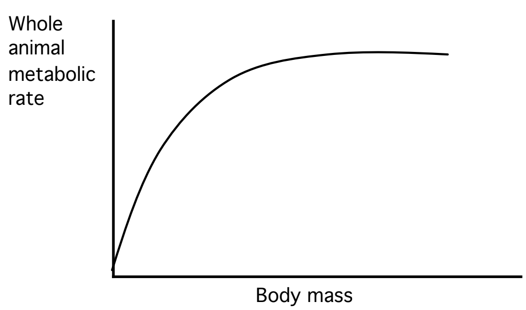
Information needed: How closely are species related and are they good dispersers that can cross oceans? If the species are not relate at all, then convergent evolution is supported. If the taxa are closely related, and are also excellent dispersers, dispersal is supported. If the taxa are related but common ancestor dates millions of years ago, and are poor dispersers, continental drift is supported (time to look for fossils). dispersers.

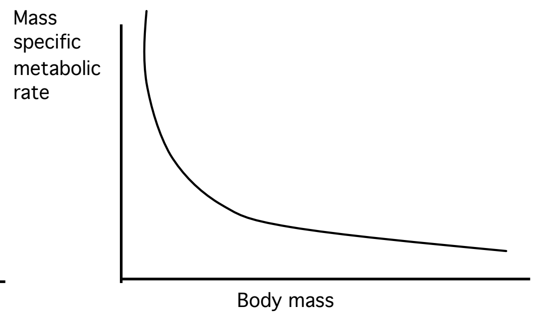
11) Match each term on the left with a term on the right that is the closest match and write the letter of the term in the space provided (5 points).

1. Wallace's Line **A**	A. continental drift
2. chaos **E**	B. movement away from home
3. stochastic model **F**	C. spatial distribution of individuals
4. risk-sensitive foraging **G**	D. Island Rule
5. dispersal **B**	E. deterministic
	F. random factors
	G. unpredictable food supply
	H. line of equilibrium in model

12. Allometry is the study of how traits or factors change in relation to body size. The relation between metabolic rate and body mass, in particular, has been the focus of intense interest and a couple of key patterns have been discovered.

(i) Fill in the graphs below with a line or curve to show the relation between whole animal metabolic rate (Kcal/unit time) and body mass (left) and mass specific metabolic rate (Kcal/gram/unit time) and body mass (right). Graphs are arithmetic, not logarithmic (2 points)





ii) Two new mammals have just been discovered in Siberia, a cow-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) or it dies, cold period is a piece of cake for the big animal

13. According to population models, the density-dependent effects of intraspecific competition can have very different and interesting consequences for the population dynamics of populations with discrete breeding seasons compared to populations with continuous breeding. These consequences are best illustrated by contrasting the population dynamics (changes in N over time) predicted by the continuous logistic ($dN/dt = rN(1-N/K)$) versus the discrete logistic model ($N_{t+1} = N_t + r_d N_t(1-N_t/K)$).

(i) What is the major difference between these models in terms of the population dynamics each model predicts when r is very high? (2 points)

Continuous gives smooth curve to K, discrete gives chaotic dynamics.

(ii) Why specifically do these two models produce such different outcomes? (2 points)

Discreteness is the key — it leads to a time lag between population growth and when density dependence kicks in. Time lags plus high r gives rise to strong overcompensating density dependence (drop below K in one time unit), then high r brings pop back above K in one time unit.