 Name_____

Before starting please **write your name on each page**! Last name, then first name.

You have tons of time. **Take your time** and **read each question carefully** to ensure you fully understand **exactly** what we are after and **don't jump to conclusions too quickly**.

SCRATCH PAPER. The last page is scratch paper for you to use to organize your thoughts.

We have worked hard to make CHALLENGING questions, not TRICK questions. Good luck

1. The Lotka-Volterra competition model allows for a graphical approach to determining the outcome of competition between two competing species. Below is a graph that needs to be completed for the following specific case: Species 2 does not impact the carrying capacity of Species 1 (this effect is represented by the parameter α). In contrast, Species 1 does affect the carrying capacity of Species 2 (the effect is represented by the parameter β). Despite the competition, both species can coexist.

(a) Fill in the graph below by adding the following: (5 points)
- the isocline for each species, indicating which one is for Species 1 versus Species 2
- the equilibrium point
- label both the x and the y axis (whole axis, not specific values where isoclines intersect axes)

(b) Assuming there is no predator involved here (i.e. just competition) what kind of experimental evidence would indicate that the **specific** outcome outlined above is occurring in nature? Describe both the experiment(s) and the result(s) from the experiment(s) needed to show the specific case shown above. (3 points)

(c) What is the general equation for change in population size of species 1 in the Lotka-Volterra competition models? (1 point)

$dN_1/dt =$

2. Each term on the left below has a matching term on right that is directly associated with it. In each space on the left write the letter of the term on the right that is the best match. (10 points).

Virulence _____	A. $K_1 = N_1 + \alpha N_2$
Life history trade-off _____	B. Inhibition
Metapopulation _____	C. Secondary compound
Senescence _____	D. $dP/dt = 1 - u/m$
$\alpha = \beta$ _____	E. Size versus number of offspring
K-selected _____	F. Indirect effect
Competition isocline _____	G. Transmission vector
Succession _____	H. $\lambda = r$
Herbivory _____	I. Ant acacia
Apparent competition _____	J. Density dependence
Mutualism _____	K. Symmetric competition
	L. Antagonistic pleiotropy

3. Developers and conservation biologists are fighting over the need to conserve three particular patches of a coastal saltmarsh to save a rare butterfly. The developers claim that these patches are not important to the butterfly because these patches are currently empty of butterflies, and that other patches containing the butterflies have already been preserved. Using the concept of metapopulations, explain why the developers might be wrong with their conclusion that the empty patches are not important to the butterflies. Your answer should explain the basic idea behind metapopulations as well as why reducing the number of patches in a metapopulation could cause global extinction (6 points).

4. You have just completed your study of a cohort of your favorite organism, the Mellow Couchpotato. You began your study by ear-tagging 1000 females, followed the entire cohort until the last one died, and noted the number of babies each female produced, on average, at each age. You then compiled all of your data and found the following: of the original 1000 newborns (age 0) you followed, 500 survived to year 1 where they had (on average) 1 baby each, 250 survived to year 2, where they had 1 baby each, 100 survived to year 3, where they had 3 babies each and none survived to year 4.

Age	Number alive	Babies/ female		
X	s_x	b_x		

(a) Is this population growing, declining or stable? To answer, complete the life table, calculate R_o and explain, based on the value of R_o, what the population is doing. (4 points)

(b) Why does the value of R_o tell you whether the population is stable, increasing or decreasing? (tell us in words what R_o represents biologically). (2 points)

(c) Complete the life table that will result in the following: a stable population (i.e. $R_o = 1$) of an annual plant where each female produces 10 seeds (seeds for female plants, we ignore males here). Consider seeds as babies (age 0) and start with a cohort of 100 total seeds. Hint: because we are dealing with an annual organism, generation time = 1, hence $R_o = \lambda$. Also, it is helpful to recall our simple life history model of λ for an annual plant. Your table should include the columns used to calculate R_o.(4 points)

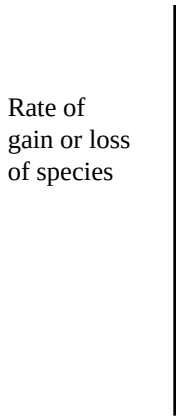
Age	Number alive	Babies/ female		
X	s_x	b_x		
0				
1				
2				

5. The Equilibrium Theory of Island Biogeography was developed to explain two interesting relationships: the relation between diversity (number of species) and (i) the size of an island and (b) the distance an island from a mainland source difference in patterns of diversity between mainland areas and islands (including distance between an island and mainland source):

(a) Draw the two species-area relationships that illustrates the two patterns described above and fully label the Y axis. The distance effect can be shown simply by comparing the mainland to islands in general (3 points)

Log Area

(b) Fill in the graph below to illustrate the how the Theory of Island Biogeography can explain why islands that are farther from the mainland source have fewer species than closer islands. Label the X axis and all of the immigration and extinction lines and be sure to indicate the equilibrium numbers of species on each of the two islands. (6 points)



(c) If you surveyed two islands of identical size and equal distance from the mainland, does the theory predict that you will find an identical list of species on two islands? Why or why not? (2 points)

6. Ecologists have long been interested in the conditions under which predators can stabilize their prey populations (i.e. keep the prey populations in check and from increasing). One aspect of predator behavior of particular interest is the 'functional response'.

(a) On the left graph below, contrast the three types of functional responses in terms of number of prey eaten per predator. (3 points).

(b) One type, in particular, is thought to be able to stabilize prey population growth rate due to density-dependent effects on prey mortality rate. Draw this type of functional response on the graph on the left and, with reference to a line for birth rate, show how this type of predation can stabilize prey populations (i.e., dN/dt of prey = 0). (Hint: pay attention to the Y axis (number or rate) and on the left, draw arrows to show where and why the population is stable). (2 points)

(c) Name one behavioral mechanism that can give rise to this type of functional response that can stabilize prey populations? (2 points)

7. Many infectious diseases show dynamics remarkably like the regular population cycles of mammals. What specifically causes an epidemic to start and what specifically causes the disease to crash or decline? With respect to these causes, why does vaccination cause the disappearance of the cycles? (5 points).

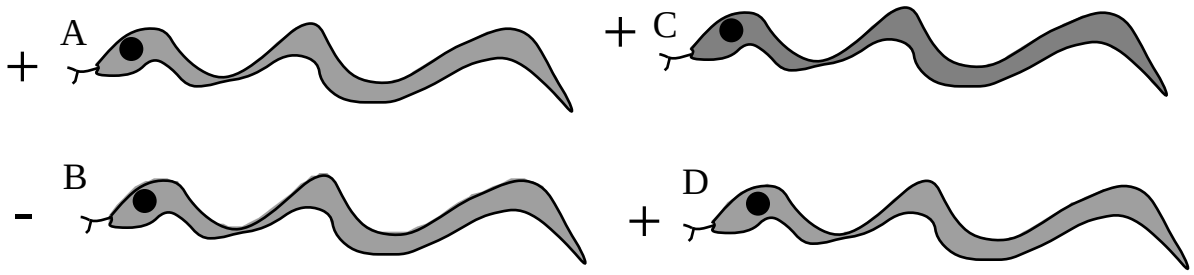
8. Below are shown four species of snakes (each species has a different letter), all brightly colored and patterned. Some snakes vary in their markings, which provide some sort of visual signal, and in their toxicity as well. Snakes with plus signs (+) are poisonous, while snakes with minus signs (-) are harmless. None of these snakes are related, so any resemblance in pattern is due to convergence, not common ancestry.

(a) Identify one species of snake that fit each of the following descriptions by filling in a letter next to each description (3 points):

Mullerian mimic_____

Batesian mimic _____

Aposomatic coloration _____



(b) Why does aposomatic coloration evolve? (2 points)

9. At times, it can be difficult to distinguish predation (and other harmful interactions) from mutualism. Show that this is so by describing predation on conifer seeds by birds that cache the seeds for the future (i.e. smart birds like jays bury the seeds and return to find them at a later date). What observations or data would you need to distinguish between the predation and mutualism hypotheses? (6 points)

10. Succession is the change in community composition over time after a disturbance. The graph below shows the relative photosynthetic rates of three species of plants, and these rates predict the relative competitive abilities between the species, for each given light intensity (i.e. the plant with the highest photosynthetic rate under the existing light conditions beats out the other species).

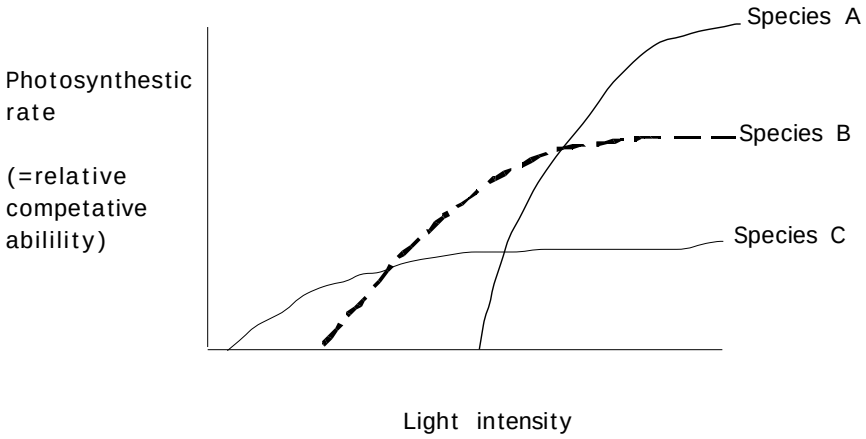
(a) What will be the order of succession (which species grows first, which second, and which third) after a disturbance, given that light levels are high immediately after a disturbance but then light levels continually decrease over time as plant grow and provide shade? (3 points)

_____ is first

_____ is second

_____ is third

(b) From the curves, draw lines down to the x axis to show the light intensities where we will see species change in the community. (2 points)



11. The following experiment is performed to assess the nature of the food web and trophic cascades in a lake. Before the experiment, the lake is crystal clear. Then, when you experimentally remove all of the individuals of one species, the Tanned Sunfish, the lake progressively gets green and scummy because of a huge buildup of phytoplankton. Previous studies showed that the Tanned Sunfish does not have any predators in the lake, and it is not a herbivore. Based on the result of the experiment, draw the food web for this lake, and indicate what trophic level the Sunfish is on and how many trophic levels were below it. Explain briefly in words how you know this (i.e., why would the number of trophic levels affect how green this lake is? (6 points)