BIOLOGY 107 Midterm Exam Winter 2014

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 deduct points for statements that are counter to the correct answer. The last page is scratch paper (work or your cartoon). 60 points. Good luck!

1. Experiments with 'risk-sensitive' foraging behavior reveal that animals sometimes "gamble".

a) Show that you understand what 'risk-sensitive' means by describing an experiment you could perform to demonstrate whether or not individual animals make 'risk sensitive' foraging decisions. What result would show that they are risk-sensitive? Be careful: we are interested in risk-sensitivity **in general** and recall there are two ways to show risk sensitivity—risk prone and risk averse—each shown by a different non-random outcome of your experiment. (5 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 animal 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*

b) Would elephants make a good experimental system to study risk-sensitive foraging? Answer yes or no and then explain the logic of your answer. (2 points)

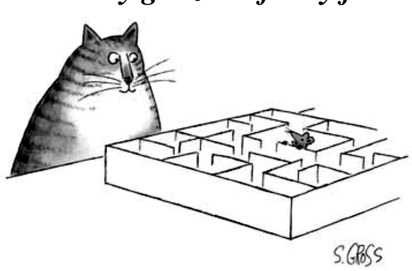
No. *Elephants would be* ***bad****. Their large size means they can last on fat for a long time so that* ***short-term unpredictability is not important to them.***

2. At time zero (t = 0) the population size of the Sneezy Weasel is 100. The annual growth rate of the Weasel population is λ = 2. What is the population size at time t = 3 years? Show the equation that allowed you to calculate your answer and show your calculations. (3 points)

$N_t = N_0 \lambda^t$ ***One point for equation, two for correct answer.***

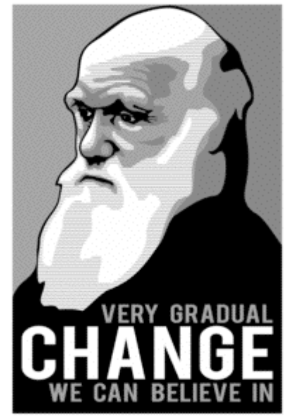
100 x 2^3 = 10 x 8 = 800 OK to write 100 x 2 x 2 x 2

They get zero if they just write 800 because they likely just copied the answer off a neighbor



"Well, you don't look like an experimental psychologist to me."

Wrong kind of risk-sensitive experiment!



Chuck E.'s in love with evolution

3. Tomorrow is Charles Darwin's Birthday!! In honor of Mr. Darwin, this question is designed to test your understanding of the process of natural selection as well as the field methods required to show natural selection in a wild population.

a) Outline the three conditions required for natural selection to occur. (3 points)

Condition

1) ***phenotypic variation in a trait***

2) ***trait is heritable (genetic) Not correct to just say genetic variation!***

3) ***trait has reproductive or survival (i.e. fitness) consequences***

b) Feral cats are introduced to an isolated island and begin to prey on the resident Island Sparrow. You suspect that this predation is causing natural selection for increased body size in the sparrow and you set out to document this selection in action. Outline exactly what you would need to do in a field study to show each of the components of natural selection outlined above: what data you would collect, how you would collect it, and what result would confirm each component of selection. Your study is an observational study (not experimental) of selection in action (just like the finches) and there is no immigration or emigration of sparrows. **Important:** the focus here is simply showing that selection for body size in the sparrow is occurring (the three parts of selection); the focus is not on figuring out what factor is causing the selection (i.e. you can ignore the cats and focus entirely on the sparrows). **Point form is preferred to full sentences**, but hit all of the key issues. (6 points)

Phenotypic Variation

- *need to capture and individually tag individual mice (so that we can follow the fates of individuals over time)*
- *need to measure the body sizes of individuals to show that there is variation in body size (part 1 above).*

Trait Affects Fitness

- *we then monitor the survival and reproduction of the mice to see who lives and dies — if natural selection favors larger mice due to predation, then we should see higher survival of larger individuals (part 3 above).*

Trait is Heritable

- *we also must match specific parents to their offspring to see if body size is heritable. We tag kids and then 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.*

4. Lake Humuhumunukunukuapua'a has an incredible diversity of fish, and they show remarkable variation in feeding morphology. You hypothesize that this might be an example of an **adaptive radiation**. (PS: this lake is named after a real fish, albeit a marine species!)

i) What single most important information is needed to confirm that this is **an adaptive radiation** and not some other pattern of diversity that results in diverse niches (Hint: Darwin missed the boat on this key aspect in the Darwin's finch radiation). (2 points)

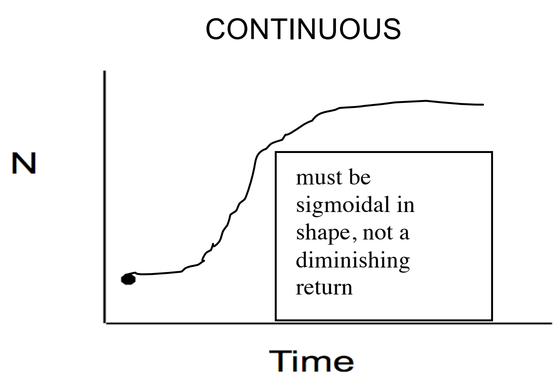
We need to show that all of these species came from a single ancestor; show that this is one clade; saying closely related without saying share single common ancestor gives them only 1 point.

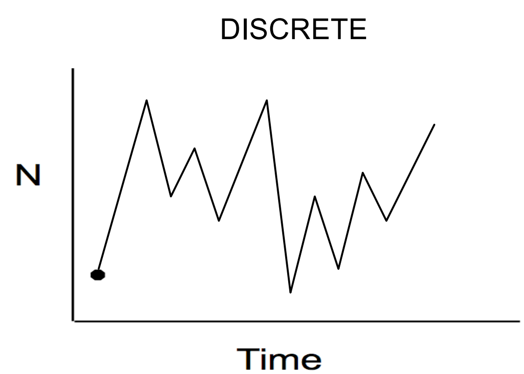
ii) Why are adaptive radiations of terrestrial organisms so often found on islands rather than the mainland? (1 point)

Islands have empty niches

5. 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 ($N_{t+1} = N_t + r_d N_t(1-N_t/K)$).

a) Show on the graphs below the major difference between these models in terms of the population dynamics each model predicts when r is very high (e.g. r = 3). The dot is the initial population size and you should project the dynamics from that initial population size. (2 points)





Should be smooth logistic *Above should show chaos (look random)*

b) Why specifically do these two models produce such different outcomes? Don't just repeat the discrete vs. continuous difference—what is the biological mechanism that differs? (1 point)

Discrete have a built in time lag before density dependence kicks in *(1 year); in continuous density dependence is instantaneously applied.*

6. Match each term on the left with one term on the right that is the BEST match and write the letter of the term in the space provided (7 points).

1. increased female body size **D**	A. random factors
2. Cocos Island finch **H**	B. continental drift
3. Arctic Circle **C**	C. summer solstice
4. Wallace's line **B**	D. fecundity selection
5. convergent evolution **J**	E. speciation + ecological specialization
6. seasons **I**	F. treeline
7. pygmy deer & giant squirrels **G**	G. Island Rule
	H. behavioral specialization
	I. tilt of the earth
	J. unrelated taxa that show same adaptations.

7. 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. (4 points)

1. Tropical rainforest **B**	A. dramatic population cycles of mammals
2. Grassland **C**	B. extreme biodiversity
3. Tundra **A**	C. fire maintains boundary in some regions
4. Temperate deciduous forest **D**	D. spring ephemeral flowers
	E. wet, warm, coniferous trees
	F. treeline separates it from adjacent biome

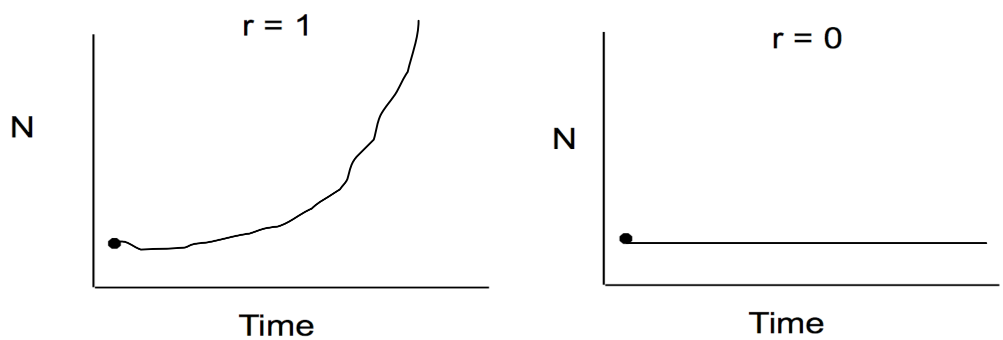
8. The population growth rate per individual, r, is a very useful population parameter that is used in many population models.

(i) In the simplest model of exponential growth, dN/dt = rN. List two assumptions of this model (2 points)

closed popn (no E, no D), continuous growth, all individuals the same, no age structure, look at females

(ii) If r = 1/day, what is r per week? (1 point) *r = 7 per week*

(iii) If dN/dt = rN, what would the pattern of population growth look like on the two graphs below? The dot is the initial population size and you should project the growth from that initial population size. (2 points)



9. You are in charge of conserving the small global population of San Francisco Garter Snakes. On your annual snake counts, you notice that the population size fluctuates, and this is also reflected in your careful estimates of λ, a measure of per individual population growth rate or decline across years. In good years λ = 3.0, in bad years λ = 0.3, and good and bad years occur with equal frequency. Your colleague insists that the snake population is in fine shape because the arithmetic mean of λ is 1.15 and plugging this value into the deterministic population model shows that the population will grow over the long-term. Being a well-trained ecologist, you correct them and insist that a stochastic population model is needed here.

a) What is the fundamental difference between stochastic population model and deterministic population models? (1 point).

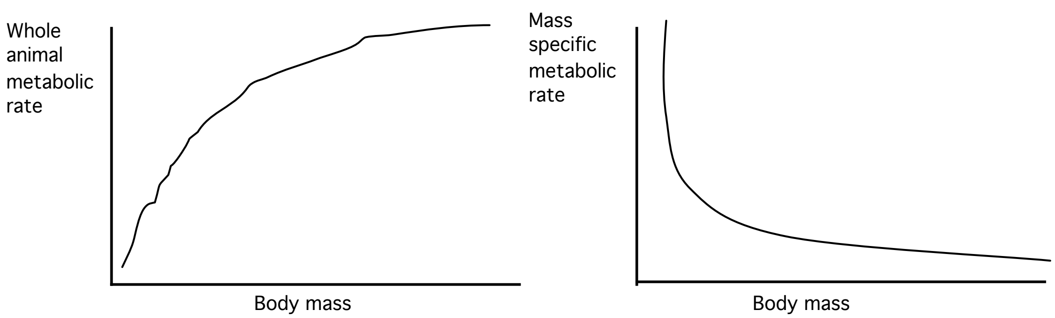
Stochastic models have ***chance or randomness*** *built in.*

b) Even without running any model you can do a quick calculation with the above λ values to obtain the appropriate estimate of some sort of 'average' λ value that accurately predicts long-term prospects for the snake population. What is the name of the average needed to predict long-term population trajectory? Show the calculation that allows you to see what the population is doing. Is the population growing, stable or declining over the long-term? Explain in terms of the value of the average you calculate. (3 points)

The snakes are in trouble . 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 and taking the square root ***-- this is the geometric mean,*** *which is used, instead of the arithmetic mean.* ***Thus, , growth rate is the square root of 3 x 0.3 = square root of 0.9, which is less than 1****. Geometric mean of lambda must be one for population to be stable.*

10. 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.

a) 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)



b) Two new mammals fossils have just been discovered in Alaska, an elephant 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 were likely to have eaten) and (ii) the risk that a three-day cold period without food would have posed to each. Justify your speculation with reference to the graphs. (2 points)

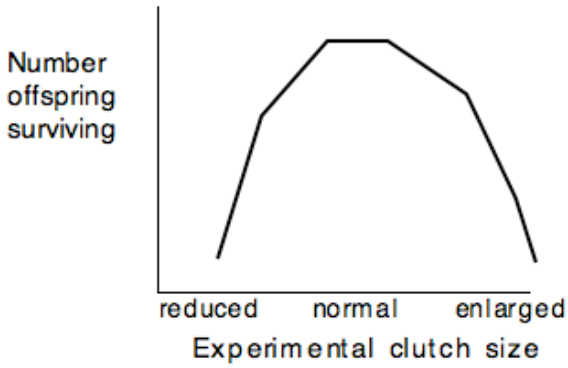
- mass specific metabolic rate huge for the tiny mammal, small for the huge animal
- thus, small animal ate energy rich food (nectar, insects); large ate low quality food (herbivore)
- endurance increases with size, tiny animal could not last cold period without dropping metabolic rate (torpor), cold period was a piece of cake for the big animal
(stating that big animals store more fat is not correct: need to mention efficiency or endurance)

11. The Ideal Free Distribution is a theory about how animals should distribute themselves among patches that differ in resources. In an experiment with fish, feeding station A dispenses 5 times more food per minute than feeding Station B. If the fish reach an Ideal Free Distribution, and Station B has 10 fish, how many fish are at Station A? State the number and show how you figured this out (**zero points if you just state the number!**) (3 points)

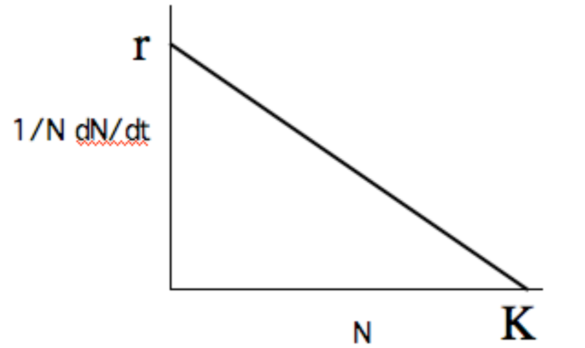
Since feeder A dispenses food at five times the rate of feeder B, there should be five times as many fish at feeder A than feeder B. To have the equilibrium condition where all fish at both stations have the same food intake rate, density must match food supply rate. Feeder A will therefore have 5 x 10 = 50 fish.

12. Fill in each graph below with the **<u>curves or lines</u>** predicted by the equation or phrase at the top of the graph beside the large letters. **For B you should also add and label the Y and X intercepts.** Read the x and y axes carefully: don't jump to conclusions. (all worth 1 point except B which is worth 3 points)

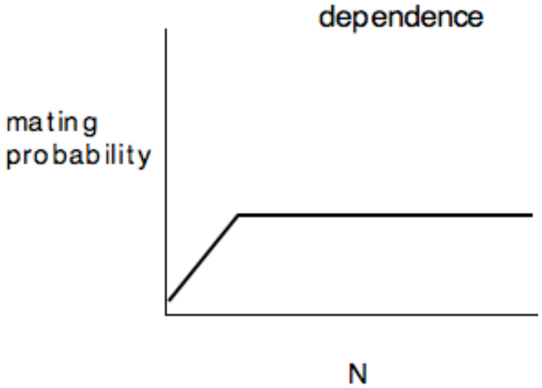
A The Lack clutch size (predicted)



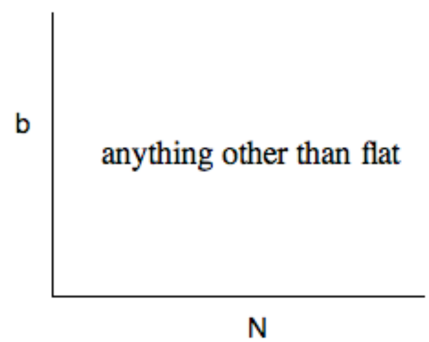
B $dN/dt = rN(1-N/K)$ $(r > 0)$



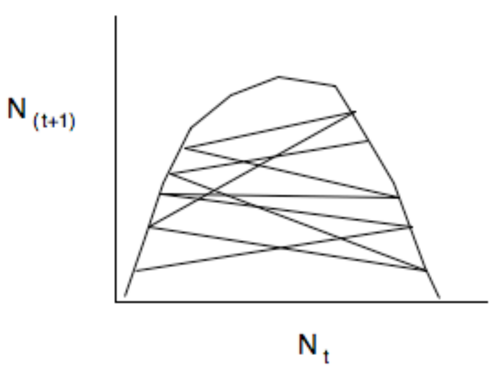
C Allee effect or reverse density-dependence



D density-dependent birth rate



E Signature of chaos: strange attractor



F Bergmann's Rule