Your name: ______________________

EEB 122b FIRST MIDTERM

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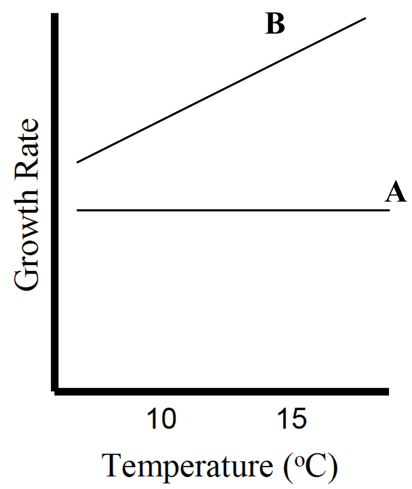
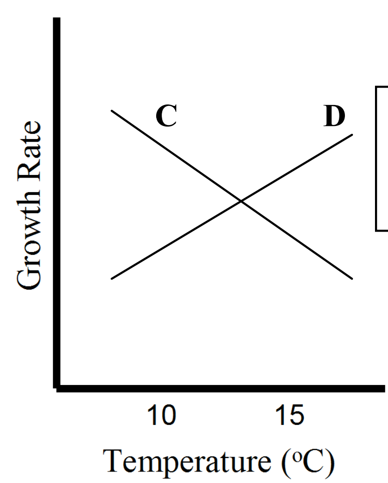
1 **Question 1**



B could have any slope (pos or neg) but must be above A for all values shown

The axes above relate individual growth rate to temperature for *Daphnia* (a water flea that can reproduce asexually). On this UPPER set of axe
(a) draw and label a reaction norm for genotype A, which does not have a plastic response to temperature (3 pts), AND
(b) draw and label a reaction norm for genotype B, which has a plastic response to temperature and a higher growth rate than A at all temperatures (3 pts).



Again, many acceptable variations exist

(c) On this LOWER set of axes, draw and label reaction norms for genotypes C and D. Genotype C has a higher individual growth rate than genotype D at 10ºC, but genotype D has a higher individual growth rate at 15ºC (4 pts).

(d) What must be true of individual growth rate if genotype C outcompetes genotype D over many generations at 10ºC, replacing it completely at that temperature? (2 pts)

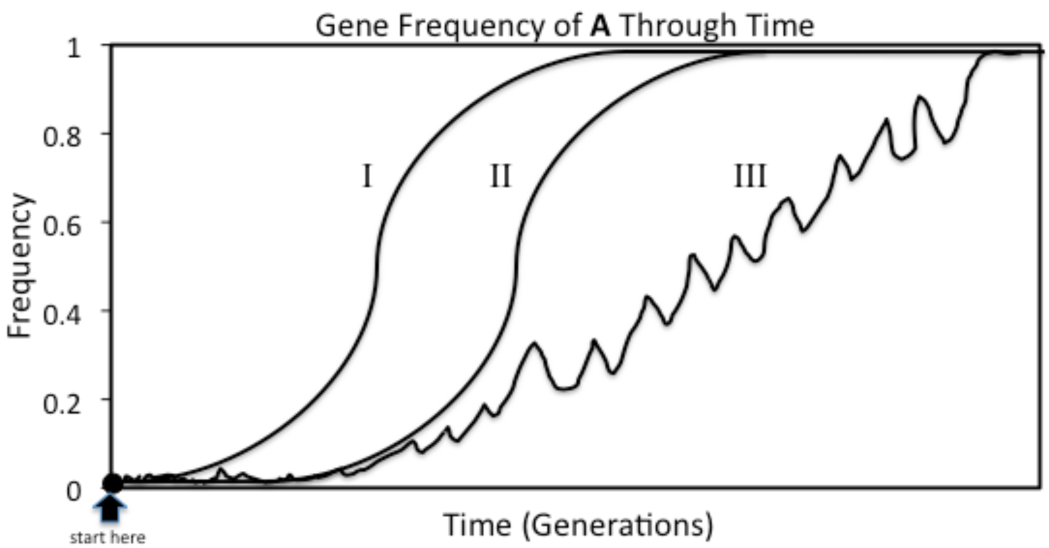
A higher individual growth rate at 10ºC must lead to higher fitness.

Question 2

A new allele **A** occurs in a large diploid population and eventually increases in frequency to fixation.

a. (6 pts) Draw and label the allele frequency of **A** from near zero at time zero (black dot at the lower left) to fixation through time (in generations) if **A** is…

I. Dominant and has a selective advantage over other alleles
II. Recessive and has a selective advantage over other alleles
III. Is neutral to other alleles (and does go to fixation)



Allele **A** has now reached fixation. A mutation then occurs that results in a single copy of allele **B** at the same locus.

b. If the population consists of 100 individuals, what is the frequency of **B**? (3 pts)

The frequency of a single mutant allele in a population of N diploid individuals = 1/2N

$$F = \frac{1}{2N} = \frac{1}{2*100} = \frac{1}{200} = 0.005$$

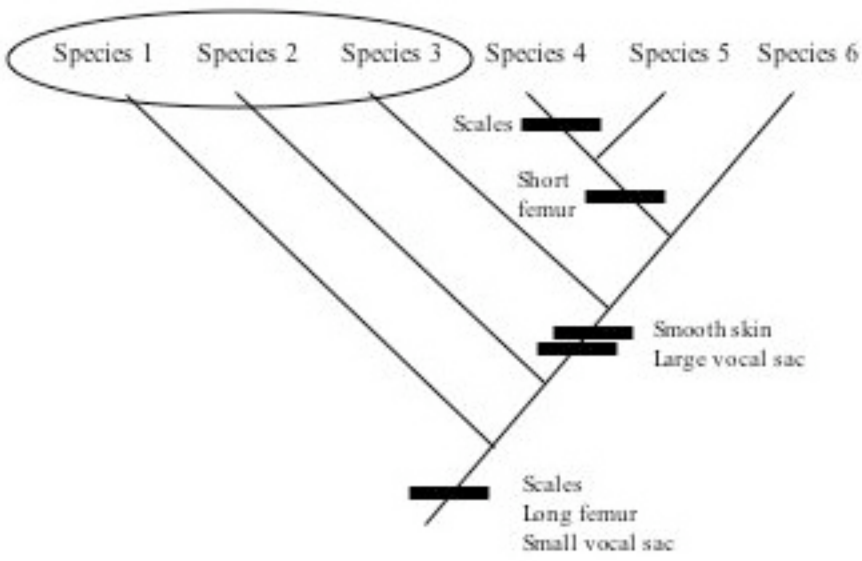
c. If **B** is neutral to **A**, what is the probability that **B** increases to fixation? (3 pts)

Probability of fixation = frequency for neutral alleles

$$P = F = \frac{1}{200} = 0.005$$

Your name: ____________________

Question 3



(a) Define homology (2pts):
Similarity in a trait among two or more species, suggesting descent from a common ancestor.

(b) Define homoplasy (2pts):
Similarity in a trait for reasons other than descent from a common ancestor, such as convergence.

(c) For the tree above, does the circle represent a monophyletic, paraphyletic, or polyphyletic group? (2pts)
Paraphyletic group because it doesn't contain all the descendants of the most recent common ancestor.

(d) For the tree above, assume the ancestor had scales, long femurs, and a small vocal sac. Which species have smooth skin, long femurs, and a large vocal sac? (4pts)
Species 3 & 6

(e) For Species 4 and Species 5, which is the shared, derived trait? (2pts)
Short femur

Your name: ____________________

Question 4

Nature has been conducting an experiment on the evolution of aging in two populations of the Virginia opossum. One population lives on mainland Georgia, the other on Sapelo Island off Georgia's coast. These populations have been separate for four to five thousand years. In the mainland population, opossums have higher extrinsic mortality rates (death due to disease, predation, or bad weather). One study found more than half of natural deaths were due to predation. Predators of mammals are absent on Sapelo Island. Other than major differences in predator pressure, the two populations are virtually the same.

a) According to the evolutionary theory of senescence, which population now has the longer life span? (5 pts)

A: Here we wanted some indication that the organisms on Sapelo island would have longer life spans because they have fewer predators and a lower extrinsic mortality.

b) What trade-offs would you expect to accompany the evolution of longer life spans? Specify the whole-organism processes involved (5 pts).

A: This question was a bit trickier. We wanted people to mention the whole organism tradeoffs of reproduction vs. maintenance, or reproduction vs. survival. Many people gave examples of specific tradeoffs that could accompany a longer lifespan without describing the larger processes that are involved.

c) What do you expect to be the characteristics of the genes underpinning those whole-organism processes? (2 pts)

A: For this we wanted people to remember that often the genes that create these trade offs are characterized by antagonistic pleiotropy. Credit was given for explaining this concept without remembering the specific name.

Question 5

Cystic fibrosis (CF) is a recessive genetic disease occurring in individuals homozygous for a mutation in the cystic fibrosis transmembrane conductance regulator (CFTR) gene. Such individuals suffer from severe lung damage over time. For people of European ancestry, the frequency of CF-causing alleles in the population is .02. In some populations, up to 4% of individuals are heterozygous carriers.

Recall that, for a diploid population, the frequency of a recessive allele under mutation-selection balance can be estimated by: $q = \sqrt{\frac{\mu}{s}}$, meaning that the mutation rate for an allele resulting in zero homozygote fitness (i.e. s = 1) would be estimated by: $\mu = q^2$. (Where q is the allele frequency, μ the mutation rate and s the relative fitness cost of being homozygous for the recessive allele.)

a. Given this information, what mutation rate is necessary for the CF allele to be under mutation-selection balance? (3 pts)

   $\mu = q^2 = .02^2 = .0004 = (4 \text{ x } 10^{-4})$

b. Given data that suggest that the actual mutation rate is $6.7 \text{ x } 10^{-7}$, does mutation-selection balance appear to be a reasonable explanation for the prevalence of the CF allele in the population? (3 pts)

   No. (The actual mutation rate is much smaller than the predicted rate under mutation-selection balance.)

c. The following table communicates the ability of *Salmonella typhi*, the bacterium that causes typhoid fever, to infect the cells of mice which have different CFTR genotypes. What hypothesis do these data suggest? (6 pts)

Mouse genotype	**# *S. typhi* per gram of mouse cells**
Wild type	569,000
Heterozygous CFTR mutant	77,500
Homozygous CFTR mutant	1.3

Full Credit: The data suggest that CFTR-mutant cells may be resistant to invasion by S. typhi. *As a result, heterozygous individuals may have a fitness advantage over homozygotes due to increased resistance to* S. typhi *while also avoiding cystic fibrosis. This heterozygote advantage may be a good explanation for the prevalence of CFTR mutations in some populations.*
Half Credit: A correct interpretation of the data, but without recognizing a possible heterozygote advantage or without connecting the data to cystic fibrosis.

Your name: ____________________

Question 6

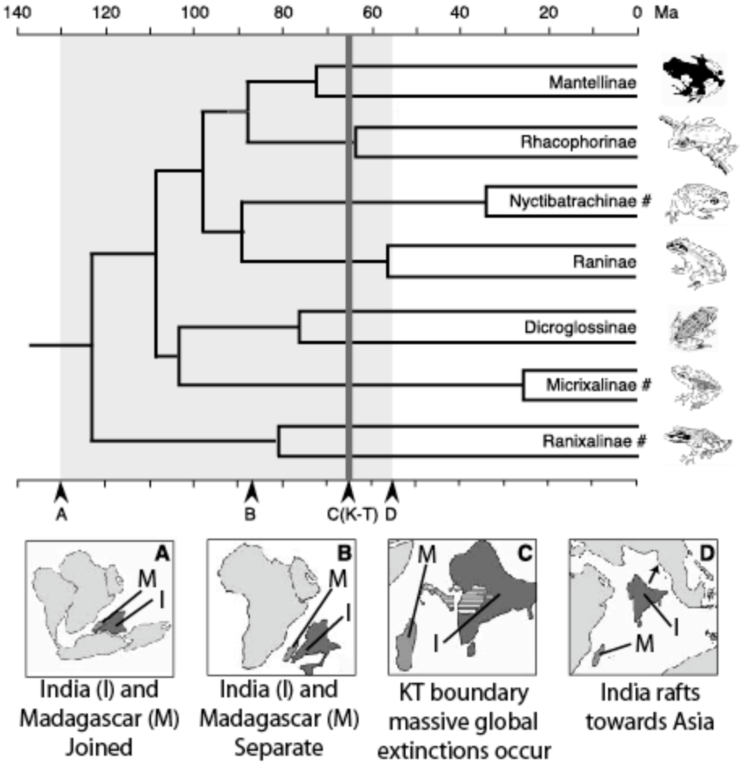


TABLE 1: Frog Trait Measurements

Name	Toe Pad Area	Body Mass
Mantellinae_1	0.204	1.467
Mantellinae_2	0.214	1.467
Rhacophorinae_1	0.225	1.465
Rhacophorinae_2	0.225	1.465
Nyctibatrachinae_1	1.265	8.565
Nyctibatrachinae_2	1.256	8.565
Raninae_1	1.236	8.565
Raninae_2	1.235	8.565
Dicroglossinae_1	0.656	3.656
Dicroglossinae_2	0.659	3.656
Micrixalinae_1	0.698	3.445
Micrixalinae_2	0.698	3.445
Ranixalinae_1	2.656	14.555
Ranixalinae_2	2.659	14.888

The above tree depicts the inferred relationships of several major frog groups, with branches proportional to time. The lower figures represent the split up of Madagascar/India and the subsequent rafting of India towards its contemporary position, with each event marked on the lower scale bar (A-D). India (I) is shaded as dark grey, Africa is shaded as light grey, and Madagascar (M) is shaded as an intermediate grey. Use the figures to answer (a) and (b) and the toe pad and body mass data to answer (c).

a.) True or False: The lineages leading to Dicroglossinae and Mantellinae diverged prior to the separation of India and Madagascar 85 Million Years ago (B). (3 pts)

TRUE

b.) The Mantellinae occur only on Madagascar, while the Rhacophorinae occur in Africa, India, and Southeast Asia, but NOT in Madagascar. State a hypothesis for the distributional pattern of the two groups consistent with the results given above. (6 pts)
For full credit you needed to have a hypothesis for BOTH groups consistent with the geologic and phylogenetic data above. You also needed to address the full geographic range of each group. There are multiple answers involving various dispersal, vicariance, or extinction hypotheses, though keep in mind that Man. and Rhac. are monophyletic groups! This was the most common answer to receive full credit: The MRCA of Man. And Rhac. occurred in the combined I and M landmass. Man. and Rhac. diverged in M around the time I and M separated. Following the KT mass extinction, all Rhac . in M went extinct. This allowed Man. to radiate in isolation. Rhac. survived the KT event in India and dispersed into SE Asia and Africa (via the middle east) after India rafted to it's present position.

c.) You want to know whether toe pad size and body mass evolve together in frogs (Table 1). What method would you use to test whether they do? Briefly explain your choice. DO NOT do any calculations or graphing of the data. (3 pts)
Independent Contrasts – species are not statistically independent samples, need to account for common ancestry.

Question 7

A virus wipes out all the waterfowl in a New Zealand watershed and temporarily removes the opportunity for the trematode *Microphallus* parasite living in ponds in this area to reproduce sexually and complete its life cycle. In response, a few *Microphallus* genotypes produce a mutation that allows them to mature in their snail host and grow asexually for repeated generations. Many generations later, you discover this population and become interested in comparing the asexual population and a nearby population of *Microphallus* with alternating sexual and asexual generations. Consider the predictions you might make about the relative fitness of the asexual population compared to the population with alternating generations.

a. Why might you expect the population with sexual reproduction to have higher fitness in the long run? (3 pts)

Sex introduces recombination and recombination increases genetic variation and improves fitness through various processes:
-Removal of deleterious mutations from the population
-Increased parasite and pathogen resistance
-Increased genetic variation increases probability of solutions to future problems

b. What conditions might favor the asexual population? (3 pts)

Small population size for both the sexual and asexual populations. The benefit of sex would be reduced by increased influence of stochastic effects in the sexual populations. In addition, the chances of encountering the opposite sex might be reduced due to low population density. The availability of the snail host as a limiting resource would also favor the faster reproducing asexual form.

c. You bring the individuals from the two populations into the lab, collect gametes, and succeed in producing hybrid zygotes. However, very few of the fertilized eggs develop into viable adults. Describe a genetic mechanism potentially responsible for this result. (4 pts)

Accumulation of fixed differences in regions where recombination has been blocked by extensive sequence divergence has resulted in reproductive isolation and incipient speciation.

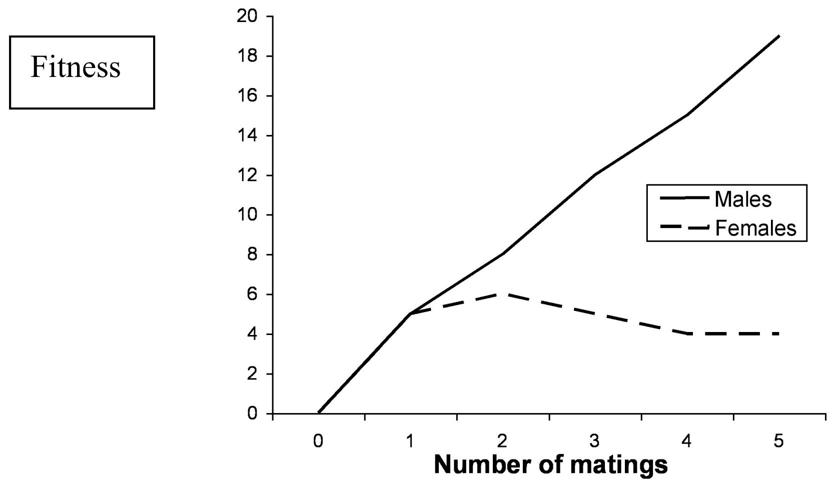
d. Name one other mechanism that might prevent formation of hybrids if the two populations were to come back into contact in the wild. (2 pts)

Various answers were acceptable, but include:
-Mate recognition
-Physical changes to sex organs

Your name: ____________________

Question 8

Bateman put equal numbers of male and female fruit flies in bottles and scored the number of matings and offspring produced by each individual using genetic markers to assign parentage.



a. What can you infer about the relative influence of number of mates on male versus female fruit fly fitness? (2 pts)

Male fitness increases linearly with increased mating opportunities. Female fitness is maximized at 1-2 mates. Females gain no further fitness benefit by mating more than twice and in fact show a slight decline in fitness with many mates.

b. What will be the operational sex ratio in a population of adult fruit flies all of whom have experienced several matings? (4 pts)

Operational sex ratio (OSR) is defined by the number of males available to mate at a given time divided by the number of females available to mate at the same time. In the mated fruit fly example, operational sex ratio will be strongly male-biased as many more males will be available to mate at a given time than females (even though the total number of males to females in the population or adult sex ratio (ASR) should start from roughly 50:50).
Credit given for description of excess males available to mate or for using data from graph above to construct a hypothetical OSR. Partial credit given for answers relating fitness gained by additional mating opportunities for each sex to a female-biased OSR, for answers discussing total numbers of a sex present in population (ASR) rather than those available to mate (OSR), or for ratios without justification from the graph or explanation.

c. Hangingfly males give nuptial gifts to females during copulation. Females copulate for longer when they receive larger nuptial gifts and males transfer more sperm to females during longer copulations. What sexual selection hypothesis is consistent with this pattern? Explain. (2 pts)

Identifying and describing the direct benefits sexual selection hypothesis (females choose mates based on the immediate phenotypic benefit available to them at mating) received full credit. Partial credit given for describing direct benefits including resource allocation/provisioning of the female without naming the idea or for naming and describing a sexual selection hypothesis *with indirect benefits to females (good genes, sexy sons, calling the nuptial gift an indicator trait etc.).*

d. Males in another fly species demonstrate an elaborate courtship dance. Female preference is correlated with a characteristic of male display. You do an experiment in whose control females are forced to mate with males chosen at random and in whose treatment females are allowed to choose among many males. You raise the offspring from both groups and follow them throughout their lives. What data do you need to gather in that experiment to test the good genes hypothesis for female preference? (4 pts)

If females choose their mates during courtship based on some indirect indicator of male quality as the good genes sexual selection hypothesis suggests, the group of females allowed to select their own mate should have higher fitness than the group of females randomly assigned. To test this hypothesis, one would need to compare the two groups for some proxy of fitness (offspring survivorship, parasite load, etc). Partial credit given for describing data that would test some other sexual selection hypothesis (for example, sexy sons), describing good genes hypothesis but suggesting data not adequate to test the hypothesis, listing generic offspring fitness, but not identifying the necessary comparisons and reasoning.