BIOLOGY 336 - Fundamentals of Evolutionary Biology
Practice Final Examination Answers

Name : _____ _____
FAMILY NAME FIRST NAME

Student Number : _____

1. Answer all questions in the space provided. Material written on blank pages will NOT be read or marked - unless it is an exact replacement for crossed-out material to be ignored in the answer-space.
2. Answers may be in sentences or point form.
3. Candidates are not permitted to ask questions of the invigilators, except in cases of supposed errors or ambiguities in examination questions.
4. No candidate shall be permitted to enter the examination room after the expiration of one-half hour from the scheduled starting time, or to leave during the first half hour of the examination. No one may leave during the final 15 min of the 150-min exam period.
5. Candidates suspected of any of the following, or similar, dishonest practices shall be immediately dismissed from the examination and shall be liable to disciplinary action:
   - speaking or communicating with other examination candidates, unless otherwise authorized;
   - purposely exposing written papers to the view of other examination candidates or imaging devices;
   - purposely viewing the written papers of other examination candidates;
   - using or having visible at the place of writing any books, papers or other memory aid devices other than those authorized by the examiner(s); and,
   - using or operating electronic devices including but not limited to telephones, calculators, computers, or similar devices other than those authorized by the examiner(s)—(electronic devices other than those authorized by the examiner(s) must be completely powered down if present at the place of writing). **You may use a non-programmable calculator.**

   The plea of accident or forgetfulness shall not be received.
6. Candidates must not destroy or mutilate any examination material; must hand in all examination papers; and must not take any examination material from the examination room.
7. Candidates must follow any additional examination rules or directions communicated by the instructor or invigilator.

I have read and fully understand these instructions, and I have checked that all 6 pages are present.

Student signature _____

Mark allocation:

Question	Marks possible	Your mark
1.	6	
2.	3	
3.	6	
4.	4	
5.	8	
6.	5	
7.	6	

Question	Marks possible	Your mark
8.	6	
9.	6	
10.	4	
11.	7	
Total	61	

1. Fill in the table below **(6 marks total)**

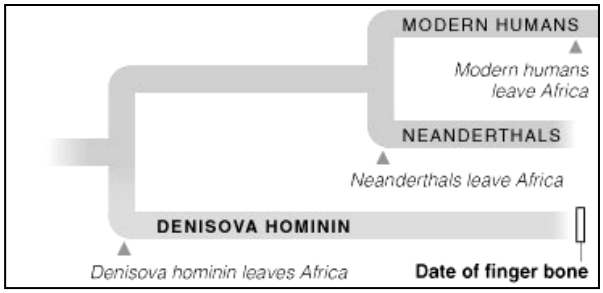
Term	Definition	List an example for each term. Briefly describe for each, why the example illustrates the distinction between the terms.
Positive Selection	*Selection favouring the fixation of a mutation.*	*An example of a trait that has been selected for because of benefits to survival or fertility.* *Description of why it illustrates the distinction between the terms.*
Sexual Selection	Selection that arises from differences, for an individual, in the relative number of fertile offspring produced over some standard time.	*An example of a trait that has been selected for because of differential reproduction.* *Description of why it illustrates the distinction between the terms.*

2. Large environmental effects on a trait (high environmental variation) decrease heritability and therefore decrease the response to selection on that trait. Explain why in 2-3 sentences. (**3 marks**)

Imagine selecting for large size, for example. When environmental effects are substantial, then many potential parents will be large primarily because of environmental effects, which are not passed on. Therefore, selecting the large parents will not necessarily produced large children, meaning that the response to selection will be small.

3. Consider the evolutionary relationship between Modern Humans (MH), Neanderthals (N) and Denisovans (D) as seen in the diagram below. **(6 marks total)**

a) What evidence (not just from the diagram) suggests that these three lineages all belong to the SAME species? What species concept is most applicable to this argument? (**3 marks**)



Evidence of interbreeding or genetic mixing.

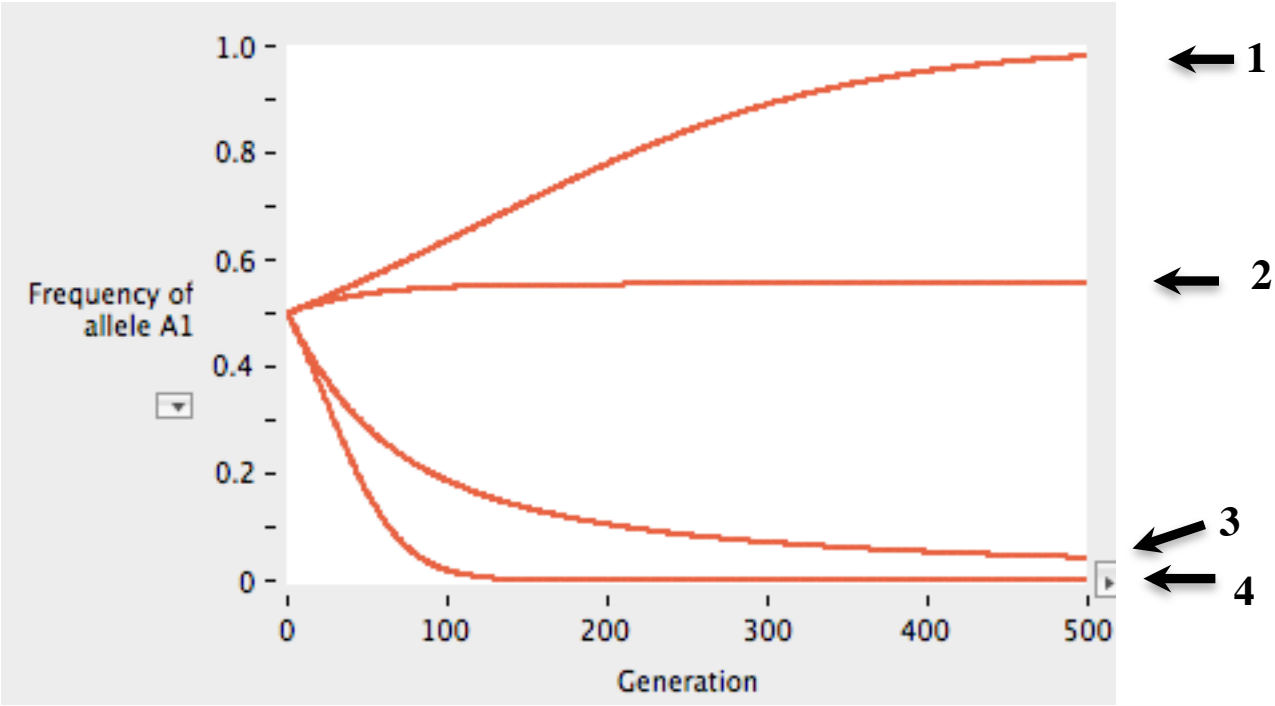
The Biological Species Concept

b) What evidence (not just from the diagram) suggests that these three lineages all belong to DIFFERENT species? What species concept is most applicable to this alternative? (**3 marks**)

Morphology (different traits or synapomorphies).

Morphological Species Concept
(or Phylogenetic Species Concept based on morphology or based on total DNA evidence)

4. Consider a gene in a population with the following features:
N = infinite; W_{A1A1} = 1, W_{A1A2} = 1.05, W_{A2A2} = 1.05; μ=0



(4 marks)

Circle the number of the line that shows change in allele A1	Explanation of shape and end point.
1 / 2 / 3 / 4	*Line 3. Allele A2 is fully dominant and beneficial compared to A1. It will therefore increase in frequency, but approach fixation very slowly. Because the y-axis is plotting the frequency of A1, this fixation will appear as a decreasing line that slowly approaches zero.*

5. In the weeks following your final exams, you and some friends from Biol 336 tutorial decide to take a three-month trek into the BC backcountry. On the second day of your trek, while stopped for lunch near a marsh, you notice that the population of snails that is polymorphic for a colour pattern. Snails have brown stripes against a background shell color that is either yellow (yy) or cream (Yy or YY). (**8 marks total**)
You spend a few hours counting snails and record the following numbers in your trip log:

Yellow background: 192 snails
Cream background: 1,008 snails

a. Calculate the frequency of Y and y for this sample. Assume Hardy-Weinberg genotype frequencies. (2 marks)

The frequency of the yy (cream) genotype is q^2 = 192 / 1200 = 0.16
The square root of this = q = 0.4 (the frequency of y), so p = 1-0.4 = 0.6 (the frequency of Y)

Three months later, on your way back, you are stunned to find that a new road now covers most of the marsh habitat and that most of the snail population has been wiped out. You look for the snails in the remaining marsh area on both sides of the road and find very few snails, but you assume they are all from the same generation of snails that you saw at the start of your trip.
Left side: 24 snails total, 6 Yellow (yy);
Right side: 16 snails total; 12 Yellow (yy).

b. It is a bad idea to assume Hardy-Weinberg equilibrium in order to calculate allele frequencies in each of these two new populations. Describe the most obvious violation of the Hardy-Weinberg equilibrium principle in these new populations. (2 marks)

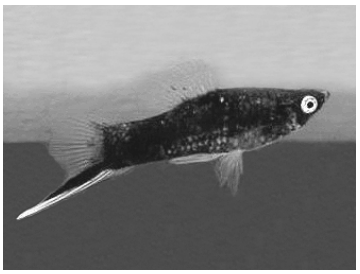
Infinite population size. Genetic drift or the action of a genetic bottleneck has severely reduced numbers within a generation; therefore, we have no expectation that the small sample that comes from the large population is in HW.

c. Have the same yellow snails on the right hand side of the road undergone evolution? Explain.
(2 mark)

No, they are the same individuals and individuals cannot undergo evolution.

d. What is one possible reproductive isolating mechanism that could evolve between the two populations if they are separated for enough generations? Describe the mechanism and define what kind of a reproductive isolating mechanism it is. (2 marks)

Many possible pre- or post-zygotic isolating mechanisms. eg. involving species recognition (colour for example), hybrid inviability or sterility.



6. In an observational study on a species of swordtail fish (male seen at right), it was found that females prefer to mate with males with longer tails. You are hired to study the possible cause of this preference. **(5 marks total)**

a) Describe how you would create four experimental groups of fish you would use to test this idea. What manipulations, if any, would you do to the fish in each group? (2 marks)

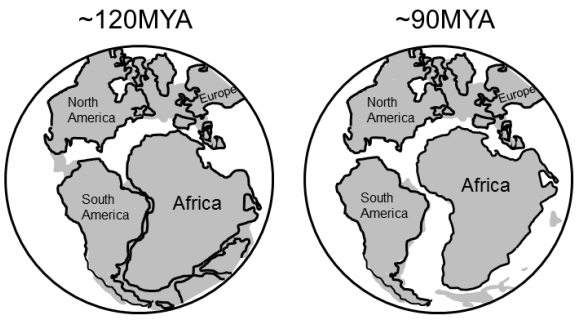
1. No manipulation
2. Tail removed and then reattached
3. Tail shortened
4. Tail lengthened

Some other answers are possible, but you need to provide four manipulations that work together in a logical way to make a complete experiment.

b) Describe a possible reason why females might choose the males with the longest tails. (3 marks)

- Sensory bias – There is some pre-existing bias in the females towards longer tails, perhaps because the males look bigger or the colour of the tail.
- Good genes hypothesis – The males must have high quality of genes to be able to produce a longer tail.
- Handicap hypothesis – The longs tail makes it harder for males to swim quickly, especially away from predators. The fact that males with long tails are still alive shows that they must have higher fitness.

7. PLEASE REFER TO THE PHYLOGENY ON THE NEXT PAGE RELATED TO THIS QUESTION. Before the mid-1990s, the monophyletic group in this DNA sequence-based phylogeny called **Afrotheria**, comprised of African mammals, did not exist. Instead, the animals in Afrotheria were classified as belonging with other clades based on morphological and anatomical similarity. (6 marks total)



The first evidence of mammals on Earth is from fossils dating back 180MY. These maps show what the Earth was like before the Afrotheria began to diversify (about 80MYA).

a) What type of speciation likely occurred between the **ancestors** of Afrotheria and the **ancestors** of their closest non-Afrotheria relatives (who actually live in the Americas)? Assume this happened between 120 and 90MYA. Explain your answer. (2 marks)

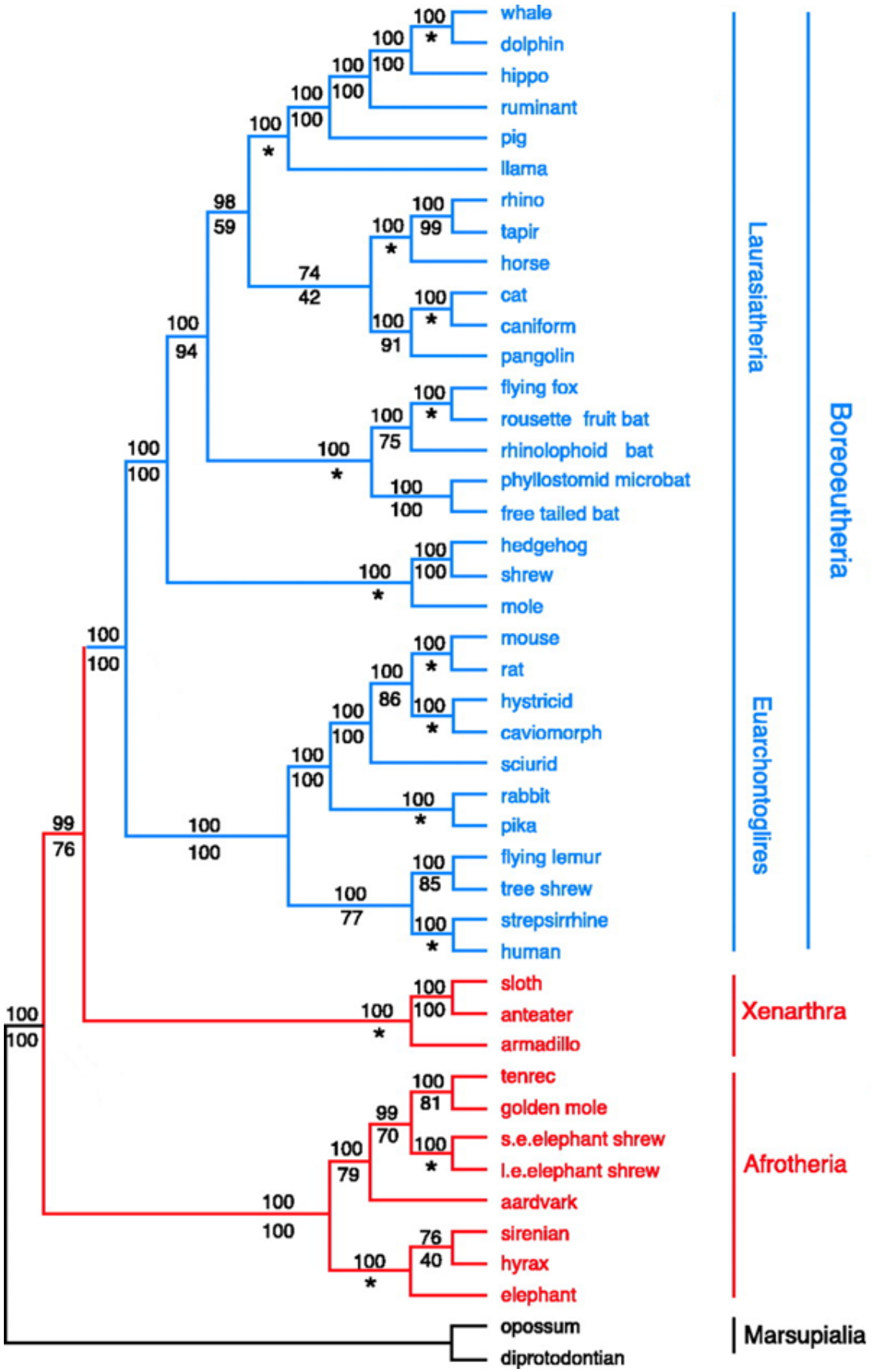
Allopatric speciation. Africa split from the other continents, creating separation between groups.

b) Would you consider Afrotheria to have undergone an adaptive radiation? Explain why or why not using the information you have in this question. (2 marks)

No. There is no sign that they are any different from other mammal species in terms of their diversity, and there were likely already some mammals on the African continent so niches were already occupied- they did not colonize Africa.

c) Your classmate tells you that based on the phylogeny, pigs are more closely related to rhinos than whales are. Identify **how** your classmate likely came to this conclusion and explain why he is or is not correct. (2 marks)

He probably counted the nodes OR read across the tips instead of looking for the common ancestor. He is not correct because there may be more lineages in we don't know about on this phylogeny, they are actually equally related


whale
dolphin
hippo
ruminant
pig
llama
rhino
tapir
horse
cat
caniform
pangolin
flying fox
rousette fruit bat
rhinolophoid bat
phyllostomid microbat
free tailed bat
hedgehog
shrew
mole
mouse
rat
hystricid
caviomorph
sciurid
rabbit
pika
flying lemur
tree shrew
strepsirrhine
human
sloth
anteater
armadillo
tenrec
golden mole
s.e.elephant shrew
l.e.elephant shrew
aardvark
sirenian
hyrax
elephant
opossum
diprotodontian
Laurasiatheria
Euarchontoglires
Boreoeutheria
Xenarthra
Afrotheria
Marsupialia

8. As an entrepreneur, you are interested in breeding a population of small rabbits, because they are cheaper to feed than average sized rabbits and there is a large demand in the pet industry for small rabbits. You obtain a random sample from a natural population of rabbits to do some breeding experiments. You conclude that the heritability of rabbit size is very close to zero.

a) (2 marks) Do these results suggest that you going to be able to get rich by breeding small rabbits from the population you have sampled? Why or why not?

There is no response to selection/the trait is not heritable, so getting rich by predictably breeding small rabbits is impossible

b) (2 marks) What do the results of your experiment tell you about the heritability of rabbit height in other natural populations? Briefly explain your answer.

Nothing. This is a particular population in a particular environment- we cannot extrapolate to other environments .

c) (2 marks) Your research on rabbit height involved some different causes of evolution. Name two (2) causes of evolution that may have occurred in the rabbit population that is associated with your experiment.

Genetic drift and selection

9. a. Explain two ways that microevolution and macroevolution are the same. **(2 marks)**

They are fundamentally the same processes over different time scales.

Possible similarities include (two required):

- *The mechanisms that ultimately drive both: mutation is responsible for variation; selection and genetic drift cause changes.*
- *The change can either be random; or the environment can shape the change so that populations and species have adaptations that allow them to survive and reproduce.*
- *Neither happens to individuals, but require more than one generation.*
- *They both involve genetic changes that can be studied by comparing differences in genomes.*

b. Explain two ways that they differ. **(2 marks)**

Possible differences include (two required):

- *Microevolution takes place at the level of the population and macroevolution can be viewed at the scale above the level of species.*
- *Studying microevolution means observing changes to the genetic and phenotypic variation within a species or population, but studying macroevolution requires comparing differences between species and higher taxa.*
- *Microevolution can be traced with allele frequencies and individual measurements of phenotypic change, macroevolution requires studying fossils, as well as genes and traits of extant organisms across the tree of life.*
- *Macroevolution involves the processes of speciation and extinction; microevolution can help us understand speciation, but only within a single species splitting into two.*

c. Define alpha and omega and explain how they can cause a reduction in species diversity on a macroevolutionary scale. **(2 marks)**

Alpha is the rate of speciation and omega is the rate of extinction within a particular lineage or taxon. Together they will determine how many species can be found in that taxon. If the diversity of a taxon is decreasing it is because omega is higher than alpha, but this can be because omega has increased, alpha has decreased or both have happened.

10. Consider the quote "Evolution is imperfect because it does not invent things from scratch: it only modifies what already exists." What evidence from the course and/or the natural world would you use to support this statement? **(4 marks)**

Many possible answers of a trait that is not optimally designed, but is a modification of an earlier trait. Examples could include the imperfect "design" of the vertebrate camera eye, or the evolution of a whale's flipper from a limb with separate finger bones, whales are fully aquatic but they have to breathe, an orchid flower which twists around 360 degrees because it evolved from a species that had twisted the flower 180 degrees to make a landing pad for pollinators, gene duplication or promiscuity, RubisCO as a very clunky enzyme that is 'poisoned' by oxygen.

11. AZT is a drug that is used to combat infection by HIV. It operates by mimicking the nucleotide thymidine and halts reverse transcription of viral genetic material into host DNA. The enzyme responsible for reverse transcription into the host genome is HIV reverse transcriptase. In most cases, treatment with AZT slows the progression of the effects of HIV when treatment begins, but after a few years it becomes ineffective because the HIV reverse transcriptase evolves to recognize AZT and does not incorporate it during reverse transcription. **(7 marks total)**

a) In many patients, treatment with AZT becomes ineffective within 6 months. Explain how this can occur due to natural selection. (3 marks)

In the HIV population, there is variation among individuals in their susceptibility to AZT. Those individuals who are resistant (or those individuals who by chance have a random, advantageous non-synonymous change) will contribute to the next generation. Over time, if resistance is heritable, there will be an increase in AZT-resistant variants in the population, eventually leading to a high frequency of variants that are resistant to AZT.

b) How could you use data on the rate of synonymous and non-synonymous substitutions (dS and dN) during an infection to find which parts of the reverse transcriptase gene are adapting? Explain your answer. (4 marks)

Adapting portions of the gene should show high ratios of dN to dS. If the ratio is above one, this indicates positive selection. If the ratio is near or below one, it still might be a signature of positive selection if that portion of the gene normally has a much lower ratio of dN to dS, i.e. when not exposed to AZT.